Mechanical World —— September 1958

INDUSTRIAL ORGANISM

AMONG industrial projects of all kinds the largest number is certainly of small or medium size. On the other hand, though relatively few in number, the big projects absorb most of the expenditure of money and effort. Moreover, it is fairly plain that big projects are becoming more numerous, and it follows from this that an increasing proportion of the specialized engineering skills is being concentrated into these industrial collections.

The finished industrial units get a good deal of publicity, and the various component products and activities provided by the various contractors come in for their share, but what is seldom heard tell of is the particular activity which conceived the whole, planned it, selected the multitude of components and services, brought them all together at the right times and places, supervised the construction and assembly and finally directed the putting to work of the completed industrial giant.

Work of this kind has not been marked by individual genius, or at least not publicly so, for there is no spectacular invention in it. The quality is there nevertheless, diffused throughout the large teams which, engaged in various special aspects of design, specification, inspection and in construction and operation, collate the work of very much larger numbers in works and factories, often at some distance. A few firms there are that specialize in this kind of work, but often it is done in engineering departments of businesses which are not themselves in any way engineers. The work is creative in a more fundamental sense than is common in industry. It is not just making something that works, but making something having many of the characteristics of a functional organism. The result is always better when this idea is followed from the inception of such a project.

PACKAGED PLANT

AT the other end of the scale in plant design from that considered in the preceding note—that is, from the large to the small—there has been development in recent years towards the self-contained or "packaged" unit. It has been publicised most in the packaged boiler plant, but exists in several forms of processing and manufacturing plant.

Originally designed to overcome the disadvantages of having to assemble various items of plant in out of the way places, the packaged plant has revealed incidental conveniences which have led to its adoption even in places where the fitting together of various items of equipment is not unusual. The very obvious attraction is the completeness offered by the unit, with nothing to be done except laying one foundation and making the several connexions. This is contrasted with having to make provision for seating several different items, perhaps involving accuracy of alignment in some cases, and fitting a lot of interconnecting service piping and wiring. The cost to the purchaser of making all these special provisions probably lends considerable weight to the alternative choice of the packaged style of plant.

MID-WATER VOYAGING

THE voyages made by atomic submarines under the polar ice have set a convincing seal on the practical capabilities of this type of vessel. The U.S. Navy's *Nautilus*' first fuelling lasted two years and sufficed for about 60,000 miles cruising. She is a large vessel and therefore of considerable carrying capacity. These factors add up to quite a lot, but the total can be looked at in two ways. First, as regards military potential it gives a new and unusual striking power, particularly as such a vessel can carry large rocket missiles. Second, as regards the commercial implications the large underwater vessel clearly only requires to be built to be proved. The advantages are hydrodynamic, meteorological and geographical. There is some advantage in sailing under the water instead of making waves, which absorb much energy, on the surface; there is no underwater weather problem; and the polar route, for one thing, shortens many of the ocean routes by some tens of hundreds of miles.

Apart from the United States there is practical interest in atomic submarines in Russia, France, and the United Kingdom. Both American and British designs are to be tried in the U.K., a programme which is not so much a duplication as a matter of equipment and also research. Nuclear powered ships and submarines are both included in the list of British projects: they are the pattern of the marine future and must be fully and rapidly developed on advanced and original lines.

LOG SHEET

New 12 ft Plate Mill

The first slab was rolled recently in the new £500,000 steel plate rolling mill at the Scunthorpe works of Appleby - Frodingham Steel Company, a branch of The United Steel Companies Limited. This marks the completion of the first stage of a £6 million development scheme which will lead to a considerable increase in the output of steel plates for the shipbuilding and constructional engineering industries. Improved surface finish, closer rolling tolerances and more accurate gauge across the width of the plate are other features associated with the mill's higher production. Initially, it will produce about 9,000 tons per week.

The new 12 ft four-high mill replaces an existing 10 ft mill which was installed nearly thirty years ago. Powered by twin 4,000 hp d.c. motors, its two work rolls weigh 29 tons each and back-up rolls 72 tons each —the heaviest rolls ever to be incorporated in a British rolling mill. Its entire operation is controlled by one man, working from a specially-designed pulpit which is equipped with the latest type of universal control system.

The mill is capable of rolling plates from $\frac{1}{4}$ in. thick upwards. The maximum rolling width of from 11 ft 4 in. to 11 ft 6in. can be used for plates $\frac{1}{2}$ in. thick and upwards.

Although the immediate effect of the installation will be to raise the company's plate output by several hundred tons per week, the full benefits of the scheme will not be realised until towards the end of next year. By that time, additional facilities will have been provided, including two new slab reheating furnaces, new cooling banks, mechanical shears, loading bay and ancillary equipment.

Cold Rolling Plant

Steel, Peech and Tozer, another branch of The United Steel Companies Limited, is to spend over £1$\frac{3}{4}$ million on the installation of a cold rolling mill and ancillary equipment adjacent to their Brinsworth continuous medium width hot strip mill. The new plan is planned to be in operation in two years' time.

The Brinsworth mill, completed last autumn, is the only mill of its kind in the country and is engaged in the continuous production of thin steel strip up to 18 in. wide. The bulk of its output is at present supplied to customers in the hot rolled condition, but when the new cold mill comes into service up to 2,000 tons of steel a week will receive a cold reduction after hot rolling.

After pickling, coils of hot rolled strip will be transferred to a tandem cold rolling mill and then annealed in either of two continuous annealing furnaces, each with a capacity of five tons per hour and fired by coke oven gas. The strip will then be rolled in a skin pass mill to improve the metallurgical properties after the annealing process and to impart a good surface finish. It will be slit to the required width in one of a number of slitting machines. The mill will be capable of cold rolling strip up to 18 in. wide to thicknesses from 0·25 in. to 0·010 in. Although able to deal with all qualities of steel, it will be primarily employed on the cold rolling of carbon steels.

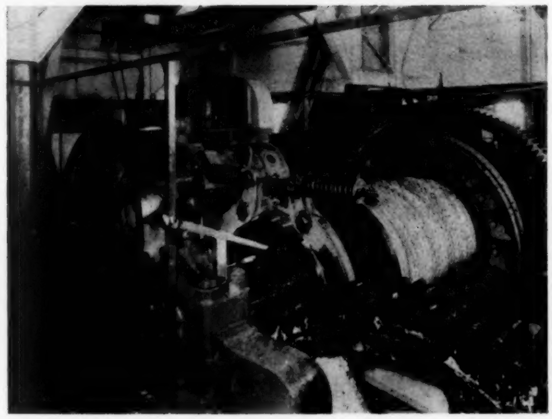
The first slab mill being rolled into plate in the new Appleby-Frodingham 12 ft plate mill

The existing cold rolling department at Steel, Peech and Tozer, which produces narrow steel strip for the strapping, tube and bicycle industries, will not be affected by this new development.

Strathfarrar Hydro-electric Scheme

The hydro-electric scheme which the North of Scotland Hydro-Electric Board propose for the Strathfarrar-Kilmorack area covers a catchment area of 350 square miles in the Counties of Inverness and Ross and Cromarty and will utilize the water of Loch Monar, Loch Beannacharan and of the River Farrar, the River Beauly and their tributary streams. It will involve the building of five dams and four generating stations for the production of 261 million units of electricity annually. The estimated cost of the scheme is £14·25 M.

Loch Monar will be enlarged to form a reservoir by a dam about one mile downstream from the loch and a subsidiary dam to the west of the main dam, and water will be led from this reservoir by a tunnel to a generating station near Deanie at the western end of Loch Beannacharan. Water from streams on the north side of the River Farrar will be collected in this tunnel and water from streams on the south side of the River Farrar, in particular the Uisge Misgeach, will be diverted back into the Loch Monar reservoir. The level of Loch Beannacharan will be raised by a dam about three-quarters of a mile downstream from its present outlet and water from the reservoir so formed will be led by tunnel from the upstream side of the dam to the Culligran generating station on the left bank of the River Farrar down-



WALKING DRAGLINE.—This is the new RapieR 300, a dragline bucket machine added to the range made by Ransomes & Rapier Limited, Ipswich. It will operate a 5 cu yd bucket at a vertical-discharge radius of 178 ft or a 7 cu yd bucket at 142 ft. The working weight is about 380 tons. The machine is designed for quick and easy erection and dismantling, being composed of units which are connected on site by welding. Erecting and dismantling do not disturb the hoisting and dragging machinery assembly on the central frame. Supply is at 3300 volts through trailing cables. A 550 hp motor generator supplies direct current to the 225 hp hoisting and two 75 hp slewing motors. The walking motion is driven from the hoist motor. Control is by the Ward-Leonard amplidyne system. The general view shows a machine working on an open-cast site at Heddon-on-the-Wall, Northumberland. The interior view is looking towards the back. The drag rope passes underneath the hoist barrel (just visible on the right) to the drag drum. The brake in the centre holds the walking shoes off the ground when the walking drive is disengaged

stream of the Culligran Falls. Water from streams on the north side of the River Farrar will be collected in this tunnel.

The level of the River Beauly will be raised by a dam north of Crask of Aigas. A generating station will be built into the dam and water from the station will discharge into the headpond formed by a dam at Kilmorack, lower down the River Beauly. A generating station will also be built into the lower dam at Kilmorack.

The Strathfarrar scheme is an important part of the North of Scotland Board's programme which is designed not only to meet the increased demand for electricity that is expected in the Board's area but also to provide peak supplies of electricity to the South of Scotland Electricity Board. The programme of the South of Scotland Board assumes that these supplies will be available. The capital cost of the scheme per kilowatt installed on present day estimates is higher than the corresponding cost of modern steam stations but hydro-electric schemes, of course, have a much longer life. It is comparable with the capital cost per kilowatt installed at nuclear stations. The cost of generation is estimated to be 0·75d. per unit. The scheme is designed for an average annual load factor of 29%, which is approximately equal to the average annual load factor of the North of Scotland Board's system and is thus most suited to their requirements. New steam generating stations and nuclear stations are most economically run at much higher load factors, and the cost of production at a load factor of 29% at a modern steam station would be 1·08d. and at a nuclear station 1·63d., and in the case of a steam station, on the continuation of present coal, labour and other running costs. For these reasons the scheme is the most economical method of providing electricity at the load factor required by the Board.

Submarine Power Cable

A second circuit in the 138,000-volt submarine power cable link between Vancouver Island and the mainland of British Columbia was put in commission in July. The cable was manufactured for the British Columbia Electric Company by British Insulated Callender's (Submarine Cables) Limited at their Trafford Park Works, Manchester. British Insulated Callender's Construction Company Limited, who were responsible for the laying and testing, chartered H.M.T.S. Monarch to transport the cable from Manchester to Vancouver and to lay the four continuous lengths between the mainland and Vancouver Island.

The existing submarine power cables, which were also manufactured and installed by the BICC Group, have been in successful operation since September 1956. These, with the two continuous lengths of 16 miles and two of about three miles, required to complete the second circuit, plus a spare cable, bring the installed length of submarine cable for this remarkable power link to a total of over 133 miles. The combined current-carrying capacity of the two circuits, which bring Bridge River hydro-electric power to Vancouver Island, is now 250,000 kilowatts, a capacity greatly in excess of that of any similar undertaking in the world.

The 138,000-volt cable is of the single-core gas-pressure type. The 0·35 sq in. conductor consists of a helical steel duct over which are applied two layers of copper wires and a conducting screen of three impregnated metallized paper tapes. The dielectric, which itself is screened with copper tape, consists of pre-impregnated paper tapes. The lead alloy sheath is reinforced by tin-coated bronze tapes over which is applied vulcanized rubber. Then follows a jute yarn bedding and a single layer of galvanized steel wire armouring. These wires are protected by two bituminized layers of jute yarn.

The overall diameter is nearly 4 in. and the weight of the entire 133-mile cable is about 5,400 tons.

Electronic Refrigeration

The principle discovered by Peltier in 1834 that the passage of electricity through junctions of two dissimilar materials creates heating or cooling depending on the direction of the current has recently been applied by the Westinghouse Electric Corporation, U.S.A., to the development of an electronic refrigeration apparatus. The device consists of 50 junctions mounted geometrically around an anodized aluminium container. This assembly is surrounded by vertical aluminium fins for dissipation of the removed heat. So far application has been to small domestic appliances.

Foundry Award

An innovation at the annual congress of the European Investment Casters Association held this year in Paris was a presentation of castings submitted by participants with a view to bringing into focus the present-day scope and application of the lost-wax casting process; highlighting specific problems overcome, developments of technique, and castings of which the manufacturers have reason to be particularly proud. Each exhibitor was allotted approximately 2½ minutes during which verbally to give the background details of the castings submitted, and subsequently, after inspection by the seventy or so representatives present (from nine countries) a secret ballot was taken for the award of two diplomas. One of these was won by Firth-Vickers; and the other by Microfusione d'Italiana of Milan.

The terms of reference of the award won by Firth-Vickers are indicated by the following extract of the citation of the diploma. "—for the casting showing the greatest promise for widening the scope of the investment casting technique." This casting is one of a set of five which, after mirror-finish machining, drilling and tapping of holes, constitutes on assembly the chassis or structural framework of an important aircraft instrument, the "artificial horizon" gyroscope. When the components were previously made as aluminium die-castings, the stresses of high-speed flight resulted in mass-shift or flexure of the instrument framework, due to inadequate strength and rigidity. As non-magnetic alloy steel was called for, the die-casting process could not be used. The greatly enhanced strength of the alloy steel components permits considerable rationalisation of design and a much higher and valuable framework/space ratio for the electrical system, etc.

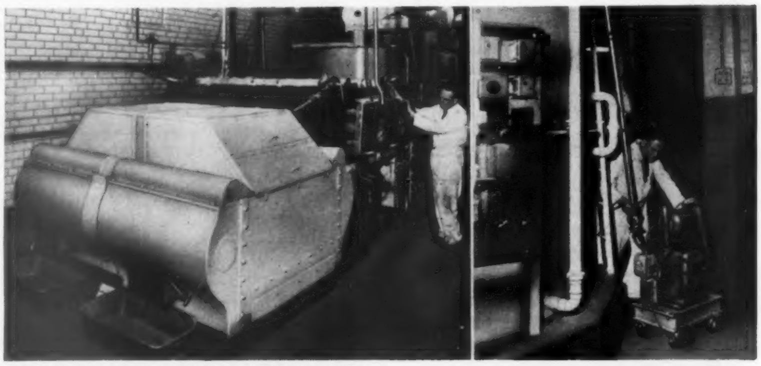
Fuel Cells

Among the items displayed on the Open Day at Sondes Place Research Institute, Dorking, Surrey, were small single fuel cells which run successfully on carbon monoxide, hydrogen, producer gas, town gas and any vaporized liquid fuel such as kerosine or petrol. A large battery with an output of between 2½ and 5 kW is under development at the institute.

This research is sponsored by the Ministry of Power. Its object is to develop primary batteries for converting the chemical energy of fuel directly into electrical energy without employing a heat engine. A fuel cell is a primary cell in which the overall chemical reaction is the oxidation of fuel to carbon dioxide and water.

The thermal efficiency of any power producing plant employing a thermal cycle is limited by purely theoretical considerations to about 38 or 40%. This is equally true of power stations running on coal, oil or atomic energy. Fuel cells are not subject to such limitations and they are able to convert the whole of the free energy of oxidation of the fuel into electrical energy. In practice thermal efficiencies between 50 and 80% are obtained.

It is not anticipated that fuel cells will be used for large-scale power generation. Their most likely uses are for small power producing units (the absence of moving parts is attractive), for transport with fuel cell batteries coupled to electric motors and running on compressed gas or vaporised liquid fuel, for the generation of low-voltage direct current for electrochemical processes, and for the utilization of waste combustible gases, especially low-grade gases with low calorific values.



The foreman has only to switch on the Megator M50 pump to start transferring chocolate from conche to storage at the Birmingham factory of Kunzle Limited. A mobile Megator M16 unit is also in use

Pumping Chocolate

Transferring liquid milk chocolate from conche to storage, formerly a job employing two men for ninety minutes with frequent spillage, has become a fully automatic, clean process taking forty minutes by the use of a Megator M50 pump at the Birmingham cake and chocolate factory of Kunzle Limited. Operation has been reduced to turning on a valve, switching on and leaving the job unattended. The foreman returns when it is convenient since the sliding shoe principle employed allows the pump to continue to run without harm upon completion of its task.

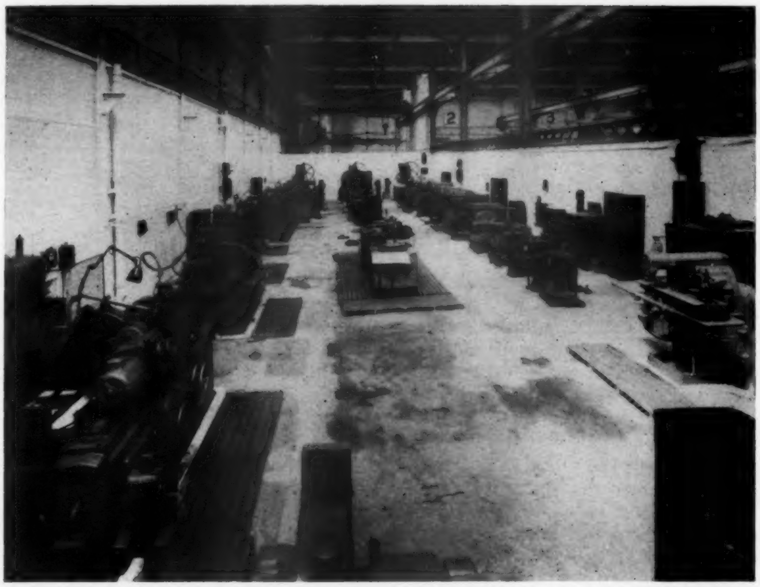
The M50 on this particular process has a 6-ft suction and delivers at a rate of six tons per hour a distance of 60 ft through 2½-in. dia stainless steel tube, temporated by Isotape.

A smaller, M16 Megator pump, supplied by Megator Pumps & Compressors Limited, 43, Berkeley Square, London, W.1, of similar design, is also used at Kunzles as a portable unit. Mounted on a castored base, it can pump from trolleys or tanks to storage at various points as required.

Channel Islands Cable

The new Post Office submarine cable laid by *HMTS Ariel* to the Channel Islands is co-axial with polythene insulation 0·62 in. dia with an inner conductor of solid copper 0·16 in. dia. The outer conductor over the polythene insulation consists of six copper tapes applied helically with an overall copper binding tape. Shore ends and land sections have additional layers of polythene insulation and an outer lead sheath. The main cable is armoured with 12, No. 2 SWG steel armour wires. The shore ends have an additional layer of armour wires for extra mechanical protection.

The ten submerged repeaters, spaced at about 13 nautical miles, are energized by d.c. fed over the centre conductor from the terminal stations and are housed in cylindrical steel housings. Special terminal equipment is installed in the repeater stations at Tuckton and St. Helier, its power units at each end providing closely regulated constant current. In the Tuckton to St. Helier direction 120 telephone channels are transmitted in the frequency range 60–552 kc/s and in the reverse direction 672–1164 kc/s.



NEW BEARDMORE TESTING DEPARTMENT.—The new Mechanical Testing Department at the Parkhead Steel Works, Glasgow, of William Beardmore & Co. Limited is sited in a modern, light and spacious building where are housed a new Losenhausenwerk Charpy test machine, a new Avery 100-ton and a new Denison 50-ton universal testing machines, and a machine shop, seen here, for the production of test pieces and specimens to the fine accuracy of British Standards. The machine shop facilities have been enlarged by the installation of a Cincinnati milling machine, a Churchill grinder, a Herbert Smallpeice profiling machine specially modified for this type of work, and two Ormerod shaping machines

Pilot frequencies 4 kc/s from the edge of each band are transmitted all the time over the system to provide continuous monitoring and control of performance. The equipment at Tuckton will enable the gain of each repeater to be measured without interfering with traffic.

At Tuckton the 120 telephone circuits will be reduced to 10, twelve-circuit carrier groups in the frequence range 60–108 kc/s, which will be extended into the inland carrier network. Equipment at St. Helier repeater station will reduce circuits to audio frequencies which will be fed to the Jersey trunk exchange.

The repeaters and cables were manufactured by Standard Telephones and Cables, and repeater housings by Submarine Cables Limited.

Severn Bridge

The new bridge to be built over the River Severn between Aust and Beachley will be a steel suspension bridge on concrete piers with steel towers 500 ft high. The main span will be 3,240 ft—slightly less than the 3,300 ft proposed for the new Forth Bridge—and each of the two side spans will be 1,000 ft. The road level, 140 ft above high-water mark of ordinary tides at the piers and 160 ft in the centre, will give a 130 ft height clearance for navigation at the centre of the span. The road deck of steel, with a thin asphalt covering, will be on top of the stiffening trusses which will be 29ft 7 in. deep. The width between parapets of the bridge will be 94 ft. Twin 24 ft wide carriageways will be constructed, divided by a 10 ft wide air gap in the centre of the bridge. Outside the main trusses, provision is made for cycle tracks and footways.

As part of the approach road the River Wye is to have a new bridge 1,517 ft long and consisting of nine steel spans carried on concrete piers. This bridge will have a width between parapets of 94 ft containing two 24 ft carriageways, cycle tracks and footways.

It is estimated that 50,000 tons of steel and 130,000 tons of cement will be required for the two bridges and approach viaducts.

With the exception of the proposed Forth Road Bridge, the only bridges larger than the Severn project are the Golden Gate Bridge at San Francisco (4,200 ft), the George Washington Bridge in New York (3,500 ft) and the new Mackinac Bridge in Michigan (3,800 ft).

Commercial Bessemer Steel Centenary

The Bessemer process of converting molten pig iron into steel by forcing a blast of air through it was patented by Henry Bessemer in October 1855 and March 1856. Its early exploitation on an industrial scale was beset with failures and setbacks, notwithstanding the success of a number of single practical experiments. Ingot steel production by the Bessemer method on an industrial scale was first accomplished in July 1858 by a Swede—Göran Fredrik Göransson, an occasion recently celebrated on the original site of the old blast furnace at Edsken in Sweden. Situated some ten miles west of Sandviken, this furnace was erected by G. F. Göransson in 1857 to experiment with the production of steel according to the Bessemer process, and in July 1858 Göransson finally succeeded in producing steel. The ingots were conveyed from there to the Högbo Forge situated on the outskirts of Sandviken. By 1862 ingot production was well established and Göransson founded the Sandvik Steel Works on the ground still occupied by the main plant of the Company.

Illustrated below are the remains of the original blast furnace near Sandviken, Sweden, with a replica of the old convertor where ingot steel was first produced on an industrial scale using the Bessemer method. Also shown is the gold medal which was presented to Sandvikens Jernverks by the Swedish Iron Masters Association (Jernkontoret) to commemorate the date of the centenary, 18th July, 1858

The Generation of Electricity in England and Wales

A review of progress, 1948-1957

By J. R. FINNIECOME, M.Eng., M.I.C.E., M.I.Mech.E., F.Inst.F., A.M.I.E.E., Consulting Engineer

IN 1950 the writer published in this journal* a critical analysis on the advances in the generation of electricity in Great Britain over a period from 1937-1947. As another decade has passed it seems most appropriate to survey the progress since vesting day, April 1, 1948, when the British Electricity Authority (B.E.A.) and its 14 area boards were established in accordance with the Electricity Act of 1947.

The British Electricity Authority (the Central Authority) had two main functions · (a) to exercise general control of the finances and policy, and (b) to generate and supply electricity in bulk to the area boards. The 14 area boards which were then formed, distributed and sold electricity to the consumers. For this purpose they bought their supplies of electricity from the Central Authority. By national co-ordination of the supply it was possible to exploit more economically the vast potentialities of electricity. These arrangements applied to the whole of England, Wales and the Southern half of England. The North of Scotland Hydro-Electric Board, established in 1943, was responsible for the distribution and sale of electricity as well as generation in the northern half of Scotland.

On April 1, 1955, under the Electricity Reorganisation (Scotland) Act of 1954, the authority's undertaking in Scotland (The South East Scotland and South West Scotland Division) and the undertakings of the two Scottish Area Boards (South East Scotland and South West Scotland) was vested in a new public authority called the South of Scotland Electricity Board and the title of British Electricity Authority was changed to Central Electricity Authority (C.E.A.) which covered only England and Wales. The authority had originally divided that system into 14 generation divisions, but from April 1, 1954, the Merseyside and North Division and the North Western Division were amalgamated to form the North West, Merseyside and North Wales Division. Consequently, there were in England and Wales 11 generation divisions and 12 area boards.

Under the Electricity Act of 1957 the Electricity Council controls the 11 Central Electricity Generating Boards and 12 Area Boards. The general functions of the Electricity Council are:

"(a) to advise the Minister of Power on questions affecting the electricity supply industry and questions relating thereto.

* 17th February, 1950.
24th February, 1950.
3rd March, 1950.
10th March, 1950

Table I.—TOTAL UNITS GENERATED, USED AND SENT OUT AT ALL POWER STATIONS AND STEAM POWER STATIONS ONLY IN ENGLAND AND WALES

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	MILLION kW-hr.						
Year ended March 31	All power stations			Steam power stations only			
	Generated	Used in station	Sent out	Generated	Used in station	Sent out	Ratio (7):(4)
1948	38,665	2,274	36,391	38,490	2,270	36,220	0·9951
1949	42,849	2,511	40,338	42,603	2,504	40,099	0·9940
1950	45,717	2,681	43,036	45,506	2,677	42,829	0·9949
1951	51,859	2,971	48,888	51,590	2,965	48,625	0·9947
1952	55,316	3,256	52,060	55,083	3,250	51,833	0·9956
1953	57,365	3,445	53,920	57,158	3,439	53,719	0·9963
1954	61,621	3 764	57,857	61,419	3,758	57,661	0·9965
1955	69,077	4,217	64,860	68,833	4,211	64,622	0·9961
1956	75,561	4,667	70,894	75,370	4,660	70,710	0·9974
1957	79,525	4,928	74,597	79,300	4,922	74,378	0·9972

Table II.—OPERATING DATA AND COSTS OF GENERATION AT STEAM POWER STATIONS YEAR ENDING MARCH 31, 1948 TO 1956

	Year		1947-8	1948-9	1949-50	1950-1
1	Number of Steam Stations	—	198	199	202	203
2	Maximum output capacity on the 31st March	kW. S.O.	10,253,000	10,590,000	11,349,000	12,128,000
3	New Generating Plant brought into commission each year since 1948	kW.	——	423,000	831,000	834,000
4	Total units generated by Steam Stations	Mill. kW. Hr.	38,490·231	42,603·269	45,508·440	51,589·746
5	Units used in the Station	Mill. kW. Hr.	2,270·160	2,504·128	2,674·814	2,963·162
6	Total units sent out from Steam Stations	Mill. kW. Hr.	36,220·071	40,099·141	42,833·626	48,624·584
7	Units used in Steam Stations in % (4)	%	5·898	5·878	6·445	5·745
8	Annaul increase in the units sent out	%	0	10·71	6·819	13·52
9	Ratio of increase in units sent out	—	1·00	1·1071	1·182	1·343
10	Fuel burnt (Coal and other Fuel)	Ton	24,042,721	26,284,668	27,859,924	31,160,028
11	Average fuel burnt per unit sent out	lb. kW. Hr.	1·487	1·468	1·457	1·435
12	Yearly average heat rate per unit sent out	B.Th.U./kW.hr.	16,316	16,076	15,904	15,732
13	Yearly average thermal efficiency (unit S.O.)	%	20·91	21·22	21·45	21·69
14	Average increase in the yearly thermal efficiency (unit S.O.)	%	0	1·483	1·084	1·119
15	Lowest yearly coal consumption	b./kW.hr. S.O.				
16	Highest yearly thermal efficiency	%	26·76	28·81	29·51	29·39
17	Average yearly load factor based on maximum demand supply	%	48·4	49·4	48·1	52·5
18	Maximum load factor of a Station	%				
19	Largest unit installed in a steam station	kW.				
20	Largest output capacity of a steam station	kW.				
21	Average cost of fuel for generation per unit sent out	d/kW. hr.	0·3788	0·3929	0·3805	0·3894
22	Average total works cost per unit sent out	d/kW. hr.	0·4799	0·4975	0·4860	0·4884
23	Average price of all fuel (excluding handling)	sh/Ton	47·56	49·95	48·76	50·64
24	Fuel cost in per cent of total works cost	%	78·94	78·98	78·30	79·73
25	Ratio of price of all fuel (excluding handling)	—	1·00	1·051	1·025	1·065
26	Average price sold to consumer	d/kW. hr. S.O.	1·144	1·187	1·208	1·188
27	Ratio of price sold to consumer to total work cost (26/22)	—	2·382	2·386	2·485	2·433
28	Station with highest thermal efficiency	—				
29	Station with lowest coal consumption	—				

"(b) to promote and assist the maintenance and development by Electricity Boards in England and Wales of an efficient, co-ordinated and economical system of electricity supply."

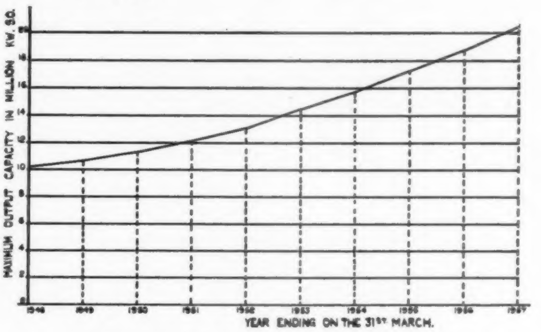


Fig. 1.—Maximum output capacity on March 31, 1948

In the following it is proposed to record the spectacular advances that have been made during the past decade. The annual reports of the British and the Central Electricity Authority contain an invaluable fund of information of statistical data, which is to form the basis of this survey. The years 1947 to 1957 represented a momentous period in the progress of the generation and supply of electricity. The real significance of the remarkable advance during the decade will be demonstrated by tables and illustrated by a series of graphs. Special attention will be focussed on the performance of steam power stations and the relative costs of generation and other facts relating to power station economy. The essence of this comprehensive survey is to present useful data to assist engineers to assess with much greater accuracy the essential factors affecting the economics of future extensions and new programmes of development.

1. Units generated and sent out

A summary of the total units generated, the units used in the station and the total sent out at all power stations and at steam power stations only, for the years 1948 to 1957 ending on the 31st March, is presented in Table I. On examining these values one finds:

(a) the units generated at all power stations during 1957 reached 79,525 million kW hr.

IN ENGLAND AND WALES

1951-2	1952-3	1953-4	1954-5	1955-6	1956-7
209	214	221	224	228	225
13,133,000	14,417,000	15,775,000	17,211,000	18,698,000	20,481,000
1,070,000	1,376,000	1,372,000	1,455,000	1,632,000	1,783,000
55,083·276	57,158·088	61,419·016	68,833·016	75,370·034	79,299·663
3,250·115	3,438·960	3,758·243	4,210·842	4,660·455	4,921·654
51,833·161	53,719·128	57,660·773	64,622·173	70,709·579	74,378·009
5·900	6·016	6·117	6·117	6·183	6·204
6·598	3·639	7·336	12·07	9·421	5·188
1·431	1·484	1·592	1·784	1·953	2·054
32,527,771	33,100,066	34,795,742	38,300,084	40,826,415	42,539,513
1·406	1·380	1·351	1·328	1·293	1·281
15,380	15,007	14,600	14,321	14,013	13,688
22·19	22·73	23·37	23·83	24·35	24·93
2·305	2·434	2·816	1·968	1·733	2·382
	0·944		0·979	0·974	0·990
29·95	30·86	30·93	31·42	30·73	31·53
51·3	49·0	46·3	48·2	48·1	47·9
	86·0		94·0	84·0	92·0
	105,000	105,000	105,000	105,000	105,000
	597,250		747,250	747,250	747,250
0·4223	0·4367	0·4545	0·4609	0·4982	0·5370
0·5277	0·5444	0·5602	0·5650	0·6045	0·6493
56·22	59·05	62·77	64·81	71·90	78·23
80·21	80·23	81·14	81·58	82·41	82·71
1·182	1·242	1·320	1·363	1·510	1·645
1·227	1·316	1·376	1·372	1·403	1·469
2·326	2·417	2·456	2·429	2·320	2·262
	Littlebrook B			Drakelow	Castle Donington
	Battersea B			Brunswick Wharf	Portishead B

(b) In that same year the units sent out were 74,597 million kW hr.

(c) The units generated in 1957 were 2·057 times those for 1947/48, i.e. approximately double in nine years.

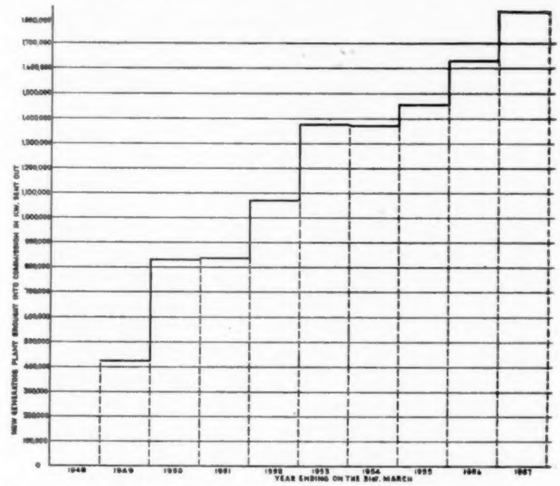


Fig. 2.—New generating plant brought into commission in kW sent out each year

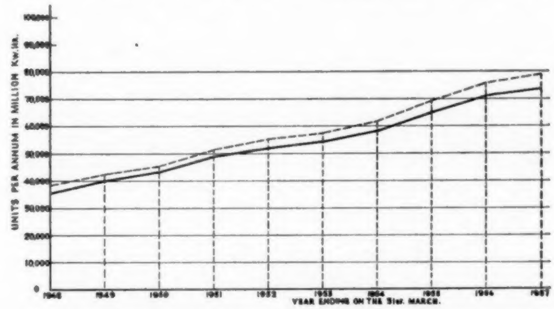


Fig. 3.—Units generated and sent out per annum in million kW hr
- - - - - - units generated
———— units sent out

(d) The units sent out from the steam stations as a percentage of the total sent out from all power stations was 99·51% for 1947/48 and 99·72% for 1956/57, representing only a slight increase.

2. Statistical data of steam power station

As the units sent out from steam stations is such a high proportion of the grand total it is proposed to direct attention to the data from steam stations only. Detailed particulars regarding operation and cost are summarised in Table II. Reference will be made frequently to this table.

3. Maximum output capacity

One finds from Item 2, Table II, that the maximum output capacity was 10,253,000 kW S.O. in 1948 and 20,481,000 in 1957, representing an increase of 99·70%. The values are plotted for each year in Fig. 1.

4. New generating plant brought into commission each year

These values are indicated in Item 3, Table II and are presented graphically in Fig. 2. The maximum annual increase was 1,783,000 kW S.O. in 1957.

5. Generation

The total units generated and sent out, the total units used in the station and as a percentage of the units

generated, the annual increase in the units sent out and the ratio of the increase in units sent out since 1948 are summarised in items 4, 5, 6, 7, 8 and 9, Table II, and presented in Figs. 3, 4, 5 and 6. A closer examination of the values reveals:

(1) in 1956/7 the units generated were 79,299·663 million kW hr and those sent out 74,378·009 million kW-hr.

(2) The ratio of the total units sent out relative to the

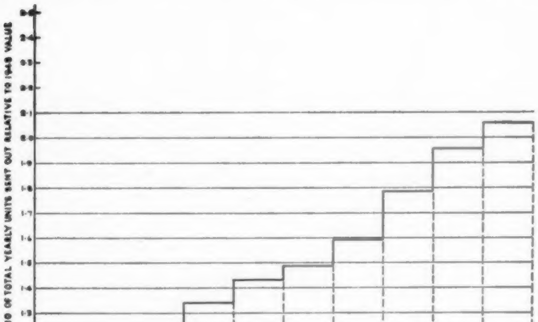


Fig. 4.—Ratio of total units sent out relative to 1948 value

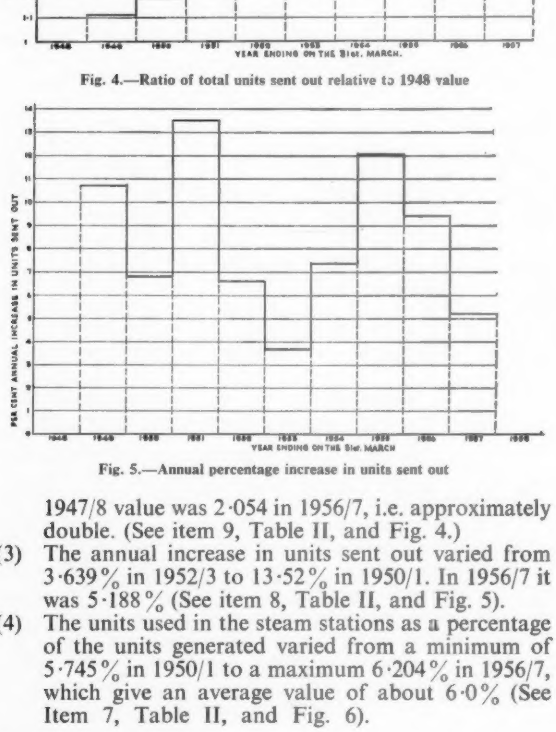


Fig. 5.—Annual percentage increase in units sent out

1947/8 value was 2·054 in 1956/7, i.e. approximately double. (See item 9, Table II, and Fig. 4.)

(3) The annual increase in units sent out varied from 3·639% in 1952/3 to 13·52% in 1950/1. In 1956/7 it was 5·188% (See item 8, Table II, and Fig. 5).

(4) The units used in the steam stations as a percentage of the units generated varied from a minimum of 5·745% in 1950/1 to a maximum 6·204% in 1956/7, which give an average value of about 6·0% (See Item 7, Table II, and Fig. 6).

6. Fuel consumption

The annual total fuel burnt in steam stations, the average consumption per unit sent out and the lowest yearly coal consumption of a power station are indicated in Items 10, 11 and 15 of Table II. On examining these annual performances one finds:

(a) the total fuel burnt in the year 1956/7 was 42,539,513 tons.

(b) the yearly average fuel burnt per unit sent out has decreased from 1·487 lb/kW-hr in 1947/8 to 1·281 lb/kW-hr in 1956/7.

(c) the lowest yearly coal consumption per unit sent out for a power station was:

1952/3	0·944 lb/kW S.O.
1954/5	0·979 ,, ,,
1955/6	0·974 ,, ,,
1956/7	0·990 ,, ,,

7. Thermal efficiencies of steam stations

7.1 Average yearly thermal efficiency (sent out basis)

These values are presented in Item 13, Table II, Fig. 7,

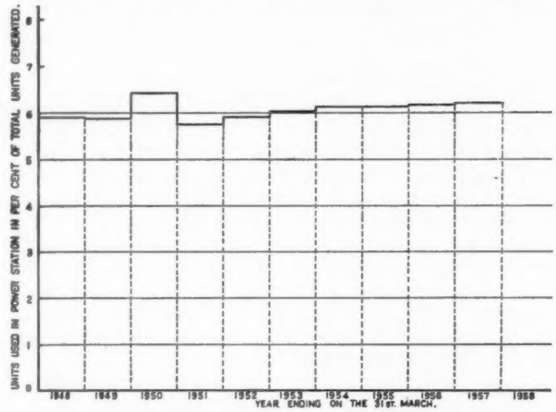


Fig. 6.—Units used in power station as a percentage of total units generated

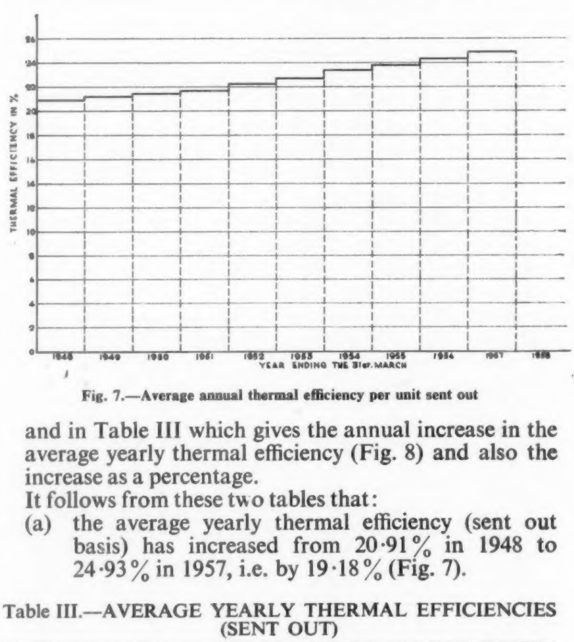


Fig. 7.—Average annual thermal efficiency per unit sent out

and in Table III which gives the annual increase in the average yearly thermal efficiency (Fig. 8) and also the increase as a percentage.

It follows from these two tables that:

(a) the average yearly thermal efficiency (sent out basis) has increased from 20·91% in 1948 to 24·93% in 1957, i.e. by 19·18% (Fig. 7).

Table III.—AVERAGE YEARLY THERMAL EFFICIENCIES (SENT OUT)

Year ended March 31	Average yearly thermal efficiency (sent out)	Annual increase in average yearly thermal efficiency (sent out)	Increase in average yearly thermal efficiency (sent out) since 1948
	%	%	%
1948	20·91	Nil	Nil
1949	21·22	1·483	1·483
1950	21·45	1·084	2·583
1951	21·69	1·119	3·731
1952	22·19	2·305	6·122
1953	22·73	2·434	8·706
1954	23·37	2·816	11·79
1955	23·83	1·968	13·96
1956	24·35	1·733	16·45
1957	24·93	2·382	19·18

(b) the annual increase has varied from a minimum of 1·084% in 1950 to a maximum of 2·816% in 1954. In 1957 it was 2·382% increase per annum (Fig. 8).

7.2 Highest yearly thermal efficiency (sent out basis)

The results are shown in Item 16, Table II, and in Table IV, which indicate the annual increase and the increase since 1948. The highest yearly thermal efficiency (units sent out) was 26·76% in 1948 and has

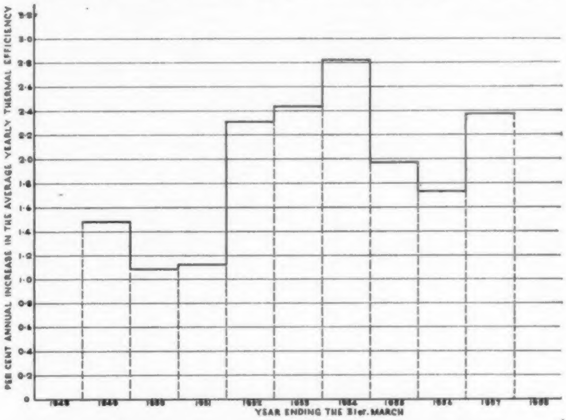


Fig. 8.—Annual percentage increase in the average yearly thermal efficiency

now reached 31·53%, corresponding to an increase of 17·82% (see Table IV, Column 4). A comparison of the highest and the average annual thermal efficiency per unit sent out each year from 1948 to 1957 is shown in Fig. 9.

The increase in percentage of the average and highest yearly thermal efficiency per unit sent out is presented in Fig. 10. It will be observed that the gap between these two thermal efficiencies has decreased, as expected, year by year.

Table IV.—HIGHEST YEARLY THERMAL EFFICIENCY (SENT OUT)

Year ended March 31	Highest yearly thermal efficiency (sent out)	Annual increase or decrease in highest thermal efficiency sent (out)	Increase in highest yearly thermal efficiency (sent out) since 1948
	%	%	%
1948	26·76	Nil	Nil
1949	28·81	7·661	7·661
1950	29·51	2·430	10·28
1951	29·39	−0·407	9·828
1952	29·95	1·905	11·91
1953	30·86	3·038	15·32
1954	30·93	0·227	15·58
1955	31·42	1·584	17·42
1956	30·73	−2·355	14·84
1957	31·53	2·604	17·82

7.3 C.E.G.B. steam stations with the highest annual thermal efficiencies per unit sent out, since 1948

These are listed in Table V which also summarises the design conditions of the boiler, turbine and reheater. It should be noted that since April 1, 1955, Portobello Power Station has been under the control of the South of Scotland Electricity Board. In 1957 Castle Donington operated at the highest thermal efficiency, i.e. 31·53%. For the year ended on December 31, 1957

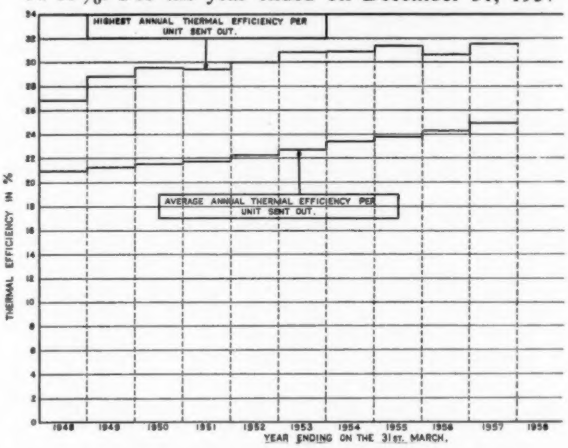


Fig. 9.—Comparison of the highest and the average annual thermal efficiency per unit sent out each year from 1948 to 1957

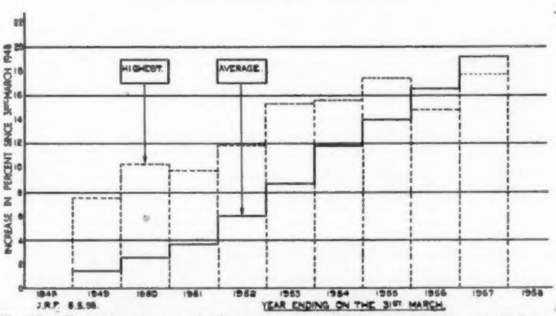


Fig. 10.—Percentage increase in the average and the highest yearly thermal efficiency per unit sent out since March 31, 1948

Castle Donington Power Station had an annual thermal efficiency (sent out) of 31·92% which represents a record for power stations in England and Wales.

7.4 Annual overall thermal efficiency per unit sent out of the best 20 C.E.G.B. steam stations for the year ended March 31 and December 31, 1957

Table V.—C.E.G.B. STEAM STATIONS WITH THE HIGHEST ANNUAL THERMAL EFFICIENCY PER UNIT SENT OUT 1948—1957

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
			Highest yearly thermal efficiency	Design Conditions								
				Boiler		Turbine		Reheater				
Year ending March 31	Power Station	Year of start up	Units S.O.	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Vacuum (At 30" Hg bar)	Final Feed Temperature	Number of feed heating stages
			%	psig	°F	psig	°F	psig	°F	In. Hg	°F	
1948	Fulham	1936	26·76	625	850	600	800	—	—	29·0	358	5
1949	Battersea—B	1940	28·81	1420	965	1350	950	—	—	29·1	400	6
1950	Battersea—B	1940	29·51	1420	965	1350	950	—	—	29·1	400	6
1951	Dunston—BII	1947	29·39	625	865	600	850	135	850	28·75	355	4
1952	Littlebrook—B	1949	29·95	1310	850	1235	825	354	825	29·15	404	5
1953	Portobello	1951	30·86	1400	960	1350	950	—	—	29·1	450	6
1954	Portobello	1951	30·93	1400	960	1350	950	—	—	29·1	450	6
1955	Portobello	1951	31·42	1400	960	1350	950	—	—	29·1	450	6
1956	Drakelow—A	1954	30·73	1550	1060	1500	1050	—	—	28·75	430	6
1957	Castle Donington	1956	31·53	1600	1060	1500	1050	—	—	28·9	430	6

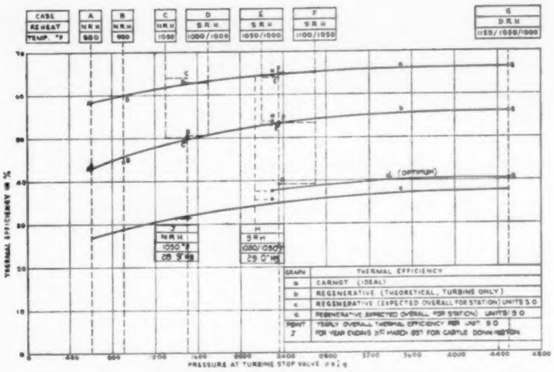


Fig. 11.—Comparison of the steam cycle thermal efficiencies with regenerative feed heating and with and without reheating

A	B	C	D	E	F	G	CASE
600	900	1500	1500	2350	2350	4500	PRESSURE
850	900	1050	1000	1050	1100	1150	TEMPERATURE
-	-	-	1000	1000	1050	1050/1000	REHEAT
28·75	28·75	28·75	28·75	28·70	28·5	28·5	VACUUM (IN.Hg.)
33·5	385	430	430	460	506	515	FINAL FEED TEMP. °F
58·3	59·69	63·87	62·63	63·87	64·65	65·73	CARNOT EFFICIENCY (%)
43·56	44·36	50·18	50·49	53·04	53·59	56·26	IDEAL CYCLE EFFICIENCY (REGENERATIVE) %
27·0	29·0	31·5	33·0	35·0	35·5	37·5	ACTUAL THERMAL EFFY. (UNITS SENT OUT) %

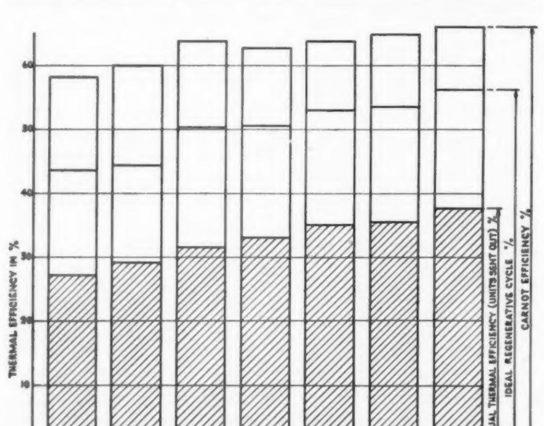


Fig. 12.—Thermal efficiencies recorded under various standard operating conditions

These operating results are presented in Tables VI and VII. The former gives also the design conditions. For the year ended December 31, Castle Donington held the record for the second year in succession of 31·92% which is 1·237% above the previous year at 31·53%. Drakelow-A, having the same design conditions except for the lower vacuum, is second in the list at 31·02%, i.e. 2·88% less.

It is of interest to add that Portobello, now controlled by the South of Scotland Electricity Board, held the record in Great Britain for three successive years, 1953, 1954 and 1955 (Table V), and operated in 1957 at an overall thermal efficiency (units S.O.) of 30·68%. Consequently Castle Donington has the best performance of any steam power station in Great Britain. Battersea-B had the highest yearly thermal efficiency in 1949 and 1950 (Table V) and is still 14th on the list for 1957.

The average yearly thermal efficiency (units S.O.) for all steam stations for the year ended on December 31, 1957 was 25·38%, whilst for the same period in 1956 it was 24·70%, corresponding to an increase of 2·753%.

8. Particulars of reheating turbine plants in Great Britain

The essential data and designed operating conditions of such plants are briefly summarised in Table VIII. The writer has been keenly interested in the progress and development of reheating plants for he was associated with the design and performance of the first reheating turbine plant in the world. It had been carefully considered in regard to economy in 1917 and was started up in Great Britain at the North Tees Power Station in 1920.

At that time the two-cylinder single shaft 20,000 kW reheating turbine had been specially designed to incorporate novel features such as high operating conditions and multi-stage feedheating. The number of reheating plants installed in this country has been exceptionally small for only eight were started up during the 37 years from 1920 to 1957.

In the period under review only the 60 MW sets at Littlebrook (1949) and just recently the first of the three 100 MW reheating turbines at Ferrybridge have been started up. However, more such reheating plants operating at higher pressures and temperatures are under construction and on order as indicated in Table VIII (Items 9 to 12); the 120 MW set for Drakelow B at

Table VI.—ANNUAL OVERALL THERMAL EFFICIENCY PER UNIT SENT OUT OF C.E.A. STEAM STATIONS FOR THE YEAR ENDING MARCH 31, 1957

	Power Station	Year of start up	Yearly overall efficiency unit S.O.	Design Conditions: At Boiler: Pressure	At Boiler: Temperature	At Turbine: Pressure	At Turbine: Temperature	After Reheater: Pressure	After Reheater: Temperature	Vacuum (at 30″ Hg bar)	Final feed temperature	Number of feed heating stages
				psig	°F	psig	°F	psig	°F	in.	°F	
1	Castle Donington	1956	31·53	1600	1060	1500	1050	—	—	28·9	400	6
2	Drakelow	1954	30·69	1550	1060	1500	1050	—	—	28·75	430	6
3	Littlebrook—B	1949	30·15	1310	850	1235	825	354	825	29·0	404	6
4	Portishead—B	1955	30·10	925	915	900	900	—	—	28·9	385	5
5	Stourport—B, H.P.	1954	30·07	1550	1060	1500	1050	—	—	28·75	430	6
6	Stourport—B, L.P.	1951	29·75	1275	975	1250	950	—	—	28·75	460	6
7	Stella South	1954	29·74	950	925	900	900	—	—	28·90	385	5
8	Barking—C	1952	29·52	950	940	900	925	—	—	29·0	400	5
9	Wakefield—B	1955	29·50	925	915	900	900	—	—	28·8	385	5
10	Dunston—B II	1947	29·31	625	865	600	850	135	850	28·75	355	4
11	Stella North	1955	29·27	950	925	900	900	—	—	28·9	385	5
12	Ince	1954	29·02	950	925	900	900	—	—	28·7	385	5
13	Meaford—B	1955	29·00	1550	1060	1500	1050	—	—	28·7	400	6
14	Hams Hall—C	1956	28·97	950	925	900	900	—	—	28·7	385	5
15	Skelton Grange	1951	28·78	950	940	900	925	—	—	28·5	400	6
16	Carrington	1956	28·68	950	915	900	900	—	—	28·6	300*, 385	4, 5
17	Brunswick Wharf	1952	28·60	925	925	900	900	—	—	29·0	365	4
18	North Tees—C	1950	28·55	950	950	900	925	—	—	29·05	388	6
19	Keadby	1952	28·51	925	915	900	900	—	—	28·7	386	5
20	Carmarthen	1954	28·44	940	925	900	900	—	—	29·0	365	5

* Sets No. 1 and 2 at 300°F, Nos. 3 to 6 at 385°F.

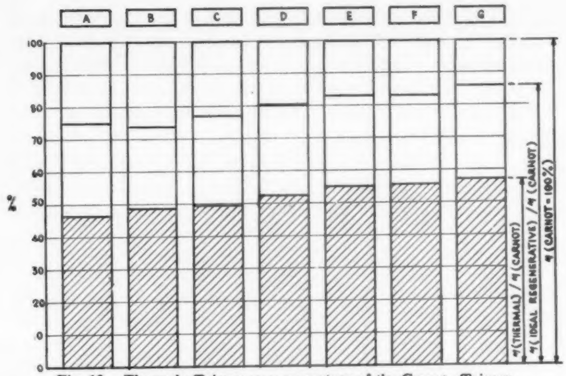


Fig. 13.—Thermal efficiency as a percentage of the Carnot efficiency

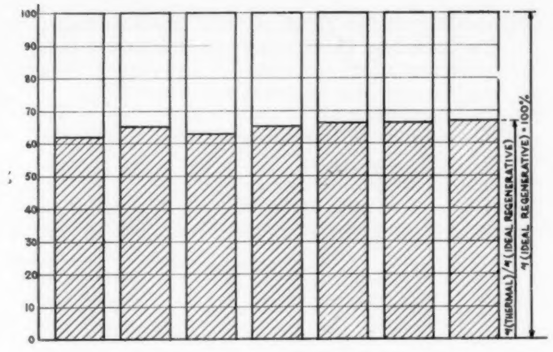


Fig. 14.—Thermal efficiency as a percentage of the ideal regenerative efficiency

1500 psig, 1000°F/1000°F; the 200 MW for High Marnham at 2350 psig, 1050°F/1050°F, the 275 MW for Blyth-B and the 550 MW cross-compound turbine for Thorpe Marsh at 2300 psig, 1050°F/1050°F. Far greater advances in the development and operation of reheating plants have undoubtedly been made in the United States. Reheating plants to a total of at least 30 million kW have been installed there, i.e. about 50% more than the grand total of steam plants in Great Britain.

9. Comparison of the steam cycle thermal efficiencies with regenerative feed heating and without or with single or double reheating

The writer has determined meticulously the various cycle efficiencies for a number of well established standard operating conditions. The results of this analysis are presented briefly in Figs. 11, 12, 13 and 14. Nine cases were specially considered, they are denoted by A to H and J. The thermal efficiencies are plotted in relation to the pressure at the stop valve in pounds per square inch gauge in Fig. 11. The relations of the various thermal efficiencies are indicated for Cases A to G in Fig. 12 and as a percentage of the Carnot efficiency in Fig. 13 and the ideal regenerative efficiency in Fig 14. Case G is of particular interest, for the operating conditions are at a super-critical pressure with double reheat, i.e. 4500 psig, 1150/1050/1000°F. Such plants are in operation in the United States and will have to be seriously considered for future power plant in this country.

Table VII.—ANNUAL OVERALL THERMAL EFFICIENCY PER UNIT SENT OUT OF THE BEST TWENTY C.E.G.B. STEAM STATIONS FOR THE YEAR ENDING DECEMBER 31, 1957

	Power station	Overall thermal efficiency for units S.O. %
1	Castle Donington	31·92
2	Drakelow	31·02
3	Littlebrook—C	30·20
4	Stourport—B (H.P.)	30·08
5	Wakefield—B	30·07
6	Portishead	29·97
7	Stella South	29·90
8	Meaford	29·83
9	Stourport	29·70
10	Stella North	29·32
11	Hams Hall—C	29·17
12	Ince	29·13
13	Barking	29·10
14	Battersea—B	29·08
15	Dunston—BII	29·01
16	Marchwood	28·95
17	Skelton Grange	28·83
18	Carrington	28·75
19	Tilbury	28·71
20	North Tees	28·53

10. Yearly load factor

In considering particularly the period of 1947/8 to 1956/7, one finds that the average yearly load factor varies from a minimum of 46·3% for 1953/4 to a maximum of 52·5 for 1950/1. The highest maximum load factor of a station in England and Wales was obtained at Castle Donington with 92·0%)Table II, Items 17 and 18).

11. Analysis of the costs of generation

11.1 Fuel costs

(a) The average cost of all fuel (excluding handling) used in steam power stations increased gradually from 47·56 shillings per ton in 1947/8 to 78·23 shillings ton in 1956/7 (See Item 23 Table II). These values are plotted in Fig. 15.

(b) the ratio of the cost of all fuel per ton relative to the 1948 value is indicated in Table II, Item 25, and Fig. 16.

Table VIII.—PARTICULARS OF REHEATING TURBINE PLANTS IN GREAT BRITAIN—1920–1963

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
					Design Conditions									Number of		
					At Boiler		At turbine stop valve		At reheater							
Item	Year started up	Power station	Maximum continuous rating of turbine	Speed	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Vacuum (30″ Hg Barometer)[2]	Final Feed Temperature	Feed heating stages	Shafts	Cylinders	Exhaust
			kW	rpm	psig	°F	psig	°F	psig	°F	in. Hg	°F				
1	1920	North Tees	20,000	2400[1]	475	700	450	650	65	500	29·25	300	3	1	2	2·5[4]
2	1930	Dagenham (Ford Co.	30,000	3000	1250	800	1200	750	200	550	29·0	420		1	3	2
3	1933	Dunston—BI	50,000	1500	625	825	600	800	151/115	800	29·0	340	4	1	2	1
4	1938	Brimsdown—A	52,607	3000	2000	940	1900	930	160	810	28·7	343	4	2	4	2
5	1946	Brimsdown—B	60,910	3000	2000	940	1900	920	315	820	28·7	362	4	2	4	2
6	1947	Dunston—BII	50,000	3000	625	865	600	850	135	850	28·75[3]	355	4	1	2	2
7	1949	Littlebrook	60,000	3000	1310	850	1235	825	354	825	29·15	421/404	6	1	3	2
8	1957	Ferrybridge	100,000	3000	1600		1500	975		950			6	1	3	2
[5]9	1958	Drakelow—B	120,000	3000	1600	1010	1500	1000	375	1000	28·7	436	6	1	3	2
[6]10	1059	Marnham	200,000	3000	2450	1060	2350	1050	405·3	1000	28·7	460	6	1	3	3
11	1962	Blyth—B	275,000	3000	2400	1055	2300	1050	565	1050	29·0	486	7	1	3	4
12	1963	Thorpe Marsh	550,000	3000	2400	1055	2300	1050		1050		486	7	2	8	8

[1]Later changed to 3000 rpm [2]At economic rating [3]At maximum continuous rating
[4]multi-exhaust [5]Rugeley, Skelton Grange—B, Uskmouth—B, Belvedere, Padiham [6]West Thurrock

(c) the fuel cost in pence per kW-hr s.o. is shown in Table II, Item 21, and Table IX, Col. 2, and Fig. 17.

This is the sum of the costs of:

(a) fuel for generation (including transport)
(b) fuel handling
(c) operating salaries and wages
(d) oil, water and stores
(e) repairs and maintenance.

These individual costs are in Table IX, Columns 2 to 6.

The total working cost is given in Col. 7 and in Fig. 17,

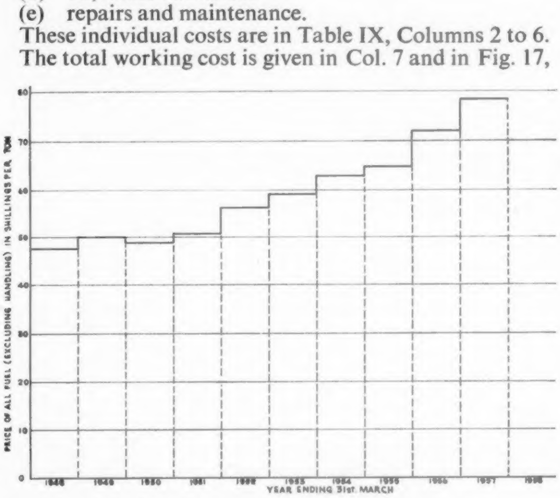


Fig. 15.—Price of all fuel (excluding handling) in shillings per ton

which shows the relationship of the fuel and the total working costs.

The fuel cost as percentage of the total working cost is indicated in Table II, Item 24, and in Fig. 18.

In examining these percentages one finds that they vary only from a minimum of 78·3% (1949/50) to a maximum of 82·71% (1956/7).

The ratio of total working cost per unit sent out relative to the 1948 value is presented in Fig. 19.

11.3. Average Price sold to consumer in pence/kW-hr s.o.

Table IX.—WORKS COSTS PER UNIT SUPPLIED FROM STEAM POWER STATIONS IN PENCE PER kW-hr IN ENGLAND AND WALES

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year ended March 31	Fuel for generation including transport	Fuel handling	Operation salaries and wages	Oil water and stores	Repairs and mainten-ance	Total work costs
	d/kW-hr	d/kW-hr	d/kW-hr	d/kW-hr	d/kW-hr	d/kW-hr
1948	0·3788	0·0255	0·0325	0·0040	0·0391	0·4799
1949	0·3929	0·0247	0·0332	0·0040	0·0427	0·4975
1950	0·3805	0·0240	0·0337	0·0040	0·0438	0·4860
1951	0·3894	0·0235	0·0319	0·0036	0·0400	0·4884
1952	0·4233	0·0244	0·0341	0·0039	0·0420	0·5277
1953	0·4367	0·0250	0·0361	0·0040	0·0426	0·5440
1954	0·4545	0·0252	0·0363	0·0038	0·0404	0·5602
1955	0·4609	0·0249	0·0361	0·0038	0·0393	0·5650
1956	0·4982	0·0255	0·0373	0·0039	0·0396	0·6045
1957	0·5370	0·0261	0·0402	0·0039	0·0421	0·6493

Table X.—AVERAGE FUEL AND TOTAL WORKS COST AND AVERAGE PRICE SOLD TO CONSUMER

(1)	(2)	(3)	(4)	(5)
Year ended March 31	Fuel cost	Average total works cost	Average price sold to consumer	Ratio (4):(3)
	d/kW-hr S.O.	d/kW-hr S.O.	d/kW-hr S.O.	d/kW-hr S.O.
1948	0·3788	0·4799	1·144	2·382
1949	0·3929	0·4975	1·187	2·386
1950	0·3805	0·4860	1·208	2·485
1951	0·3894	0·4884	1·188	2·433
1952	0·4223	0·5277	1·227	2·326
1953	0·4367	0·5444	1·316	2·417
1954	0·4545	0·5602	1·376	2·456
1955	0·4609	6·5650	1·372	2·429
1956	0·4982	0·6045	1·403	2·320
1957	0·5370	0·6493	1·469	2·262

These figures are recorded in Table II, Item 26, and Table X, Col. 4. The ratio of the price sold to customer to the total working cost can be obtained from Table II, Item 27, and Table X, Col. 5. One finds that this ratio only varies from 2·382 in 1948 to 2·262 in 1957.

12. Reduction of generating capacity

During Mondays to Fridays of December and January the reduction in generating capacity due to breakdown, overhaul and other causes as a percentage of

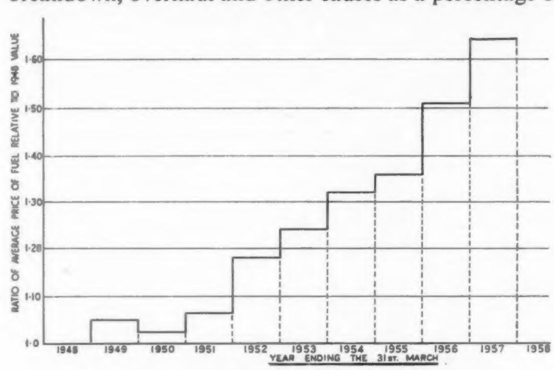


Fig. 16.—Ratio of average price of fuel relative to 1948 value

the maximum output capacity with all plants in service is summarised in Table XI, Cols. 2, 3 and 4, with the total in Col. 5. The minimum value was 8·5% for 1955/6 and the maximum 15·1% for 1947/8. It was 10·5% for 1956/7.

13. Number of generation employees per thousand kilowatt output capacity

These are listed in Table XII, which indicates that the total generation employees per 1000 kW output capacity has decreased from 2·74 in 1948 to 1·86 in 1957. The

Table XI.—REDUCTION OF GENERATING CAPACITY DURING MONDAYS TO FRIDAYS OF DECEMBER AND JANUARY EXPRESSED AS PERCENTAGES OF THE MAXIMUM OUTPUT CAPACITY WITH ALL PLANT IN SERVICE

(1)	(2)	(3)	(4)	(5)
During December and January	Reduction in generating capacity due to			
	Breakdown	Overhaul	Other causes	Total
1947/8	7·6	3·3	4·2	15·1
1948/9*	6·4	4·1	3·0	13·5
1949/50*	5·8	3·2	2·7	11·7
1950/1*	7·6	3·1	4·3	15·0
1951/2*	6·4	3·0	3·1	12·5
1952/3*	7·4	3·1	3·1	13·6
1953/4*	7·5	2·5	2·4	12·4
1954/5*	6·2	2·7	2·4	11·3
1955/6	4·1	1·6	2·8	8·5
1956/7	5·9	2·6	2·0	10·5

* Including Southern Scotland.

Table XII. STEAM POWER STATIONS IN ENGLAND AND WALES

Number of generation employees per thousand kilowatts of output capacity

(1)	(2)	(3)	(4)	(5)	(6)
Year Ended March 31	Technical and supervisory staff per 1000 kW	Workmen on operation per 1000 kW	Workmen on repairs and maintenance per 1000 kW	Total generation employees per 1000 kW	Total generation employees at power station
1948	0·27	1·37	1·10	2·74	28,079
1949	0·29	1·38	1·14	2·81	29,273
1950	0·30	1·30	1·10	2·70	32,637
1951	0·31	1·27	1·06	2·64	31,188
1952	0·31	1·23	0·99	2·53	32,009
1953	0·30	1·16	0·92	2·38	32,806
1954	0·29	1·08	0·83	2·20	33,340
1955	0·27	1·02	0·77	2·06	33,996
1956	0·26	0·97	0·73	1·96	35,094
1957	0·25	0·91	0·70	1·86	36,420

total number of employees at the power stations was 36,420 in 1957.

14. Employees of the Authority and the area boards

The total number of employees and the various grades as a percentage of the total for the year ended 1954 to 1957 inclusive are contained in Table XIII. It will be observed that the percentage of each grade varies only very slightly, the average values being:

		%
(a)	Managerial and higher executives	0·7
(b)	Technical engineering	8·6
(c)	Executive, clerical, accountancy, sales, etc.	22·3
(d)	Manual	64·3
(e)	Technical trainees and apprentices	4·1

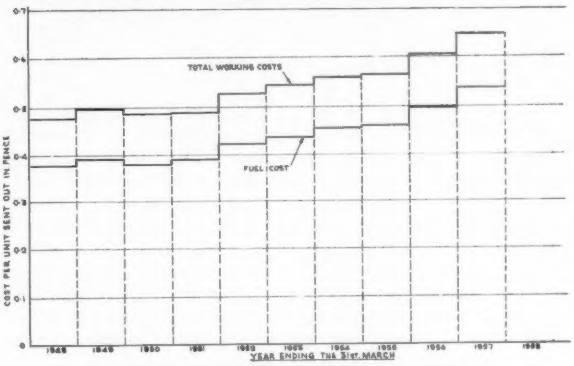


Fig. 17.—Ratio of the fuel cost and total working costs

15. Analysis of combined expenditure, combined revenue and surplus

It is particularly instructive to bring to the notice of power station engineers the annual expenditure and its distribution for the various purposes. Such a summary is presented in Table XIV. The total combined expenditure consists of:

(a) Fuel (Col. 2)
(b) Other materials, goods and services (Col. 3)
(c) Salaries, wages and related expenditure (Col. 4)
(d) Rents, rates and insurances (Col. 5)
(e) Capital charges (Col. 6).

The total combined expenditure and the combined revenue and surplus are indicated in Columns 7, 8 and 9 respectively. In 1957 the combined revenue was £422·82M, the combined expenditure £411.1M and the surplus £11·72M. One finds that in earlier years the surplus was about half, as shown below:

Year ended March 31	Total Combined Expenditure £M	Total Combined Revenue £M	Surplus £M
1950	207.3	214.46	7.16
1951	230.65	236.98	6.33
1953	284.35	291.65	7.28

On examining these expenditures one finds, for instance for 1957, that these are distributed as a percentage of the total in the following manner:

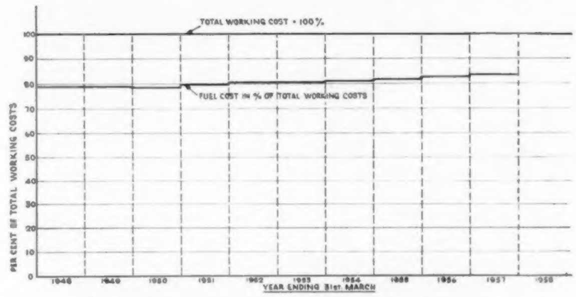


Fig. 18.—Fuel cost as a percentage of the total working cost

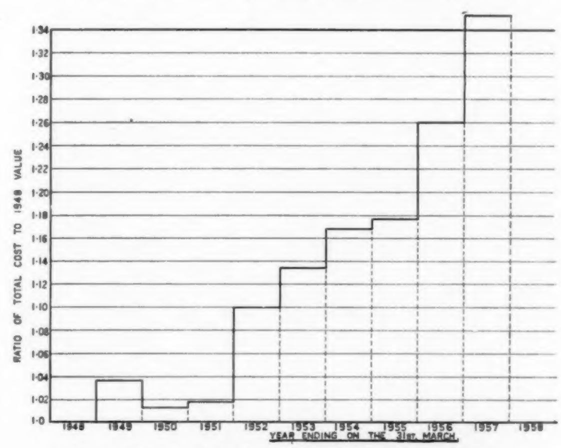


Fig. 19.—Ratio of total work cost per unit sent out to 1948 value

		%
(a)	Fuel	40·55
(b)	Other materials, goods and services	6·97
(c)	Salaries, wages and related expenditure	20·51
(d)	Rents, rates and insurances	4·67
(e)	Capital charges	27·30
(f)	Total (a+b+c+d+e)	100·00

It is of interest to note that the capital charges are 27·3% of the total expenditure.

Table XIII.—EMPLOYEES OF THE AUTHORITY AND THE AREA BOARDS FOR THE VARIOUS GRADES AS A PERCENTAGE OF THE TOTAL EMPLOYEES (COL. 7)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Year ended March 31	Managerial and higher executives	Technical engineering	Executives, clerical, accountancy, sales, etc.	Manual	Technical trainees and apprentices	Total employees (100%)
	%	%	%	%	%	
1954	0·7	8·5	22·3	64·6	3·9	184,711
1955	0·8	8·4	22·1	64·8	3·9	190,022
1956	0·7	8·6	22·4	64·1	4·2	180,923
1957	0·7	8·7	22·3	64·0	4·3	182,924

Table XIV.—ANALYSIS OF COMBINED EXPENDITURE, COMBINED REVENUE AND SURPLUS IN £M

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	EXPENDITURE							
Year ended March 31	Fuel at delivered cost	Other material, goods and services	Salaries, wages and related expenses	Rents, rates and insurances	Capital charges	Total combined expenditure	Total combined revenue	Surplus (8)—(7)
1954	117·14	26·34	68·62	16·93	84·33	313·36	326·55	13·19
1955	132·93	28·67	73·99	18·86	92·44	346·89	365·68	18·79
1956	147·12	26·46	77·30	18·45	98·92	368·25	380·46	12·21
1957	166·69	28·45	84·37	19·20	112·2	411·1	422·82	11·72

Hydraulic Couplings and Converters

Hydraulic power transmission units offer smooth take-up and good flexibility, features commonly lacking with mechanical clutches. The hydraulic converter is also a torque converter, distinct from a fluid coupling, and is capable of providing the equivalent of stepless gearing. Converters and converter-couplings are coming into prominence in all industrial fields.

THE hydraulic torque converter, as distinct from a fluid coupling, is capable of yielding variable torque multiplication and as such can provide stepless gearing to dispense with the need for a mechanical gearbox. Torque converters are finding increasing favour for all forms of drives and as complete transmission units—e.g. to replace the clutch and multi-shift mechanical gearboxes on tractor drives, etc.

The simple hydraulic coupling consists of two basic elements—a bowl-shaped impeller attached to the drive shaft and a runner or turbine wheel attached to the driven shaft. Both bowls have radial vanes and the free volume between them is filled* with the working fluid (usually oil). The impeller, effectively, acts as a centrifugal pump driven by the engine, imparting energy to the fluid and causing it, by virtue of the geometry of the arrangement, to impinge on the runner or turbine blades, where its kinetic energy is given up. The resulting reaction causes the turbine to rotate in the same direction as the impeller.

Strictly speaking, although the circulation of working fluid involved is the means by which the transfer of energy is achieved, the drive force is dependent on the rapid change of oil velocity rather than speed of circulation. Circulation, too, depends on a degree of slip being present, which may range from a matter of 100% when the turbine shaft is stalled down to some 2-3% at design load-speed. It is this characteristic which provides the smooth take-up and flexibility associated with hydraulic couplings (Fig. 1).

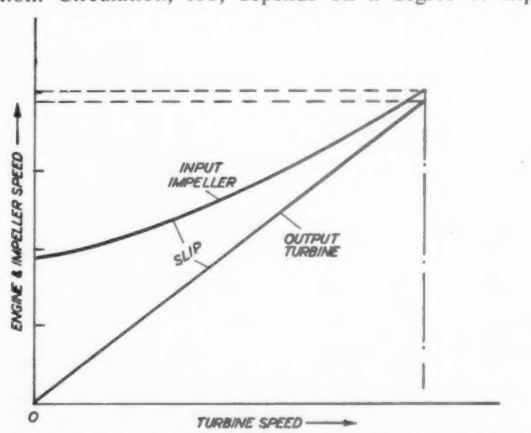


Fig. 1.—The driving force is dependent on the rapid change of oil velocity. Oil circulation too is dependent on the degree of slip

* In the scoop controlled coupling provision is made for varying the quantity of oil in circulation, hence giving control over the speed of the output shaft of the coupling.

If, for example, the output load is increased beyond the capacity of the coupling, the coupling will merely increase its slip whilst the engine continues to develop its full torque. Actually this is not quite true. An increase in slip will result in an increase in pumping action or centrifugal pressure, which in turn will increase the rate of circulation of the fluid. Hence there will be a slightly increased load on the input shaft causing some loss of engine speed. With the output shaft fully stalled the slip will, however, have increased to 100% and the engine will be loaded only by the 'residual drag' of the coupling and thus will not stall with the load.

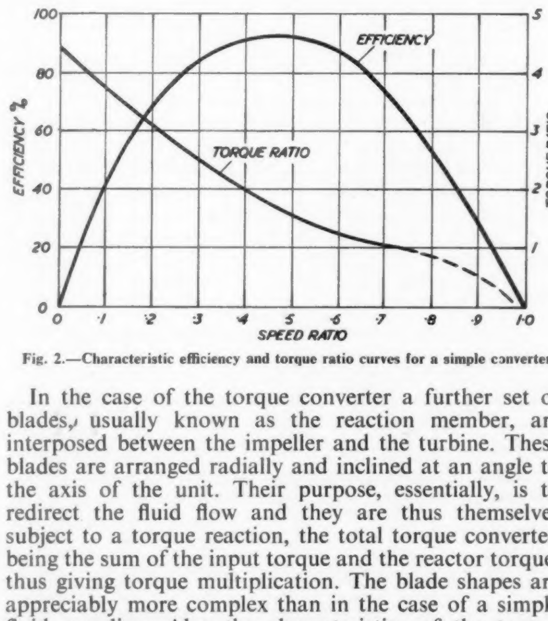


Fig. 2.—Characteristic efficiency and torque ratio curves for a simple converter

In the case of the torque converter a further set of blades, usually known as the reaction member, are interposed between the impeller and the turbine. These blades are arranged radially and inclined at an angle to the axis of the unit. Their purpose, essentially, is to redirect the fluid flow and they are thus themselves subject to a torque reaction, the total torque converted being the sum of the input torque and the reactor torque, thus giving torque multiplication. The blade shapes are appreciably more complex than in the case of a simple fluid coupling. Also the characteristics of the torque converter can be altered by fixing the reaction member so that it cannot rotate, or mounting it in such a way that it is free to rotate or freewheel in the same direction as the impeller and turbine but locked to the frame with respect to opposite direction of rotation.

In a simple converter, characteristic efficiency and torque ratio curves are of the form shown in Fig. 2. Efficiency is nil at zero speed ratio, and again nil at a speed ratio of 1. The torque ratio curves flatten out to reach a value of unity at some particular speed ratio which is known as the clutch point or coupling point of the converter.

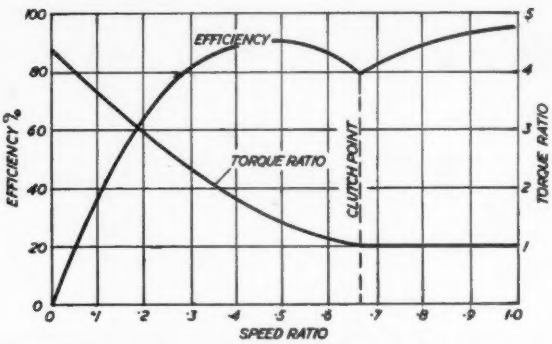


Fig. 3.—With free rotation of the reaction member at the clutch point, converter efficiency continues to rise with increasing speed ratio

At the clutch point the converter is then acting as a straightforward fluid coupling. Any increase in speed ratio beyond the clutch point would result in a negative torque reaction on the reaction member yielding a braking effect. If, however, the reaction member is free to commence rotating with the turbine at the clutch point there is no braking effect and the efficiency, instead of falling off, rises again with increasing speed ratio, and maintains normal fluid coupling performance (Fig. 3). Alternatively, in some forms of drive utilising a simple converter, provision is made at the clutch point to disconnect the fluid drive and change over to direct mechanical drive once a torque ratio of unity is reached. The type of converter which obviates this with a free-wheeling reaction member is commonly referred to as a converter coupling.

The converter can also be largely free from residual drag for the reaction member can be designed to assist impeller speed under heavy overloads—e.g. inclining the vanes towards the direction of engine rotation will assist in maintaining impeller speed with increasing fluid circulation. The ultimate performance of the converter, in fact, is largely bound up with the design and arrangement of the blading in order to achieve the most desirable results.

A converter coupling is appreciably more flexible as regards design capacity than a simple converter as an oversize coupling will maintain a similar working efficiency at all speeds. Also for any particular output speed efficiency increases with decreasing load, whereas the reverse is true over a wide speed range with the simple converter. With low loads, too, there is appreciably less heat to be dissipated which, in the case of simple converters running for prolonged periods under 'no load' conditions, may call for special attention to cooling or restrictions on engine speed for 'no load' running.

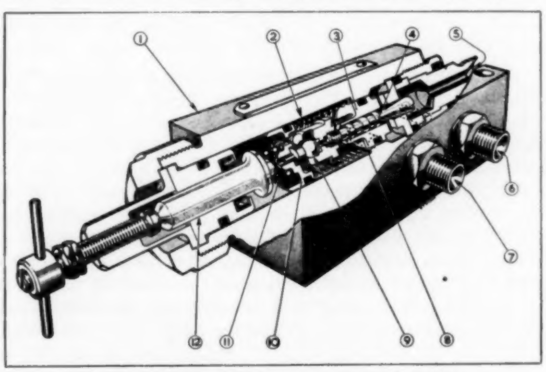
Pressure Metering Valve

After being successfully employed for over three years in the Vickers Viscount aircraft brake control relay valve system, the Goodyear pressure metering valve has now been developed for industrial use as a means of controlling the pressure supply to a hydraulically operated device. The valve illustrated will meter pressure from a 3000 psi supply to a maximum delivery pressure of 1500 psi to control varying loads. It can be operated either by a lever or a screw jack, applied to the operating plunger according to the type of control required. The valve shown measures $7\frac{3}{4} \times 1\frac{1}{2} \times 2\frac{7}{8}$ in. and normally operates with a 3000 psi supply pressure, but will maintain its maximum output pressure of 1500 psi when the supply pressure is as high as 4000 psi or as low as 1550 psi. By a change of balancing spring the maximum delivery pressure can be increased to the maximum supply pressure of 4000 psi.

The variable pressure output is achieved without a constant drain of fluid to return. Fluid is only returned when pressure is released.

The valve consists of a body (1) with a bore containing a valve unit (2) which is controlled by a plunger (12). The valve in the illustration is operated by a screw jack, but this may be replaced by a lever if the installation calls for it. The supply pressure enters the valve unit through the coupling (6), similar couplings being provided for the delivery pressure (5) and a return to the pump or reservoir (7).

When the plunger (12) is pushed in, the balancing spring (11) transfers the applied movement to the balance valve sub-assembly (3). The spring bears on the pusher (10) which moves the steel ball (9) on to its seat sealing off the return passage through the stem of the conical poppet valve (4). Simultaneously, the poppet valve unseats allowing a metered hydraulic pressure to be applied to the equipment being operated. The delivery line pressure acting over the cross-sectional area of the ball through the hollow poppet valve stem, compresses the balancing spring and allows the poppet valve to close under action of its return spring (8). At this instant the delivery line pressure is just sufficient to balance the effective load of the balancing spring. When the load on the plunger is reduced, the load on the balancing spring is correspondingly reduced and the steel ball is pushed off its seat by the delivery line pressure, thus opening the return line. As soon as the delivery line pressure is in balance with the balancing spring, the steel ball seals off the return passage. If the load on the plunger is completely removed, the ball is free to unseat as the pusher is held clear of the ball by the pusher return spring.



Cut away view of the Goodyear pressure metering valve

To give some indication of the performance accuracy the makers, The Goodyear Tyre & Rubber Company (G.B.) Limited, Aviation Products, Wolverhampton, Staffs, quote the following set of figures:

(1) With a steady supply pressure and the maximum pressure stop set at any value above 150 psi, the maximum variation in delivery pressure is $\pm$ 25 psi.

(2) With the maximum pressure stop set at any value above 150 psi, and the supply pressure allowed to fluctuate between 4000 and 150 psi above the pre-set delivery pressure, the maximum delivery variation at this set stop is $\pm$ 50 psi.

Cushioned Gear Drives

When flexibility is required in a gear drive it may range from very slight movement to complete slippage. The devices surveyed cover the full power range from the very light to the very heavy, and take account of unusual working conditions

By R. WARING-BROWN

A MODERN trend in all classes of machine construction is replacement of belt drives by gearing. Belt drives when properly designed with correct belting materials for the job are highly efficient. A notable instance is the new U.S.A., positive drive flat belt of neoprene-nylon construction, for which a 99% efficiency is claimed. Further, belts present one very important advantage in their capacity to absorb load reactions, shock and vibration. Obviously then, it is the space that a belt takes up and the fact that it is generally exposed that has led to a return to gearing in some applications.

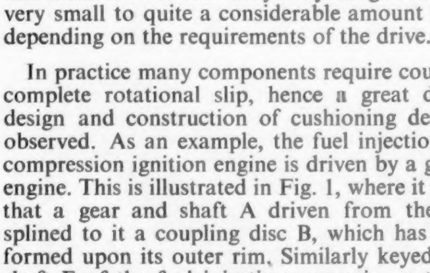
The gear drive while normally more intricate and expensive lends itself to total enclosure, and enables the designer to produce a compact arrangement especially suitable to the unit construction now the vogue for all classes of machinery and mechanism. At the same time it will be appreciated that a solid gear drive may be subjected to wear and possible damage resulting from shock, vibration and alternate stressing. These objections have been overcome by the introduction of resiliency in the drive, usually by adopting some spring element in the gears themselves, or by some form of flexible coupling mounted between the gear and the driven element of the mechanism. This resiliency may range from something very small to quite a considerable amount of springing, depending on the requirements of the drive.

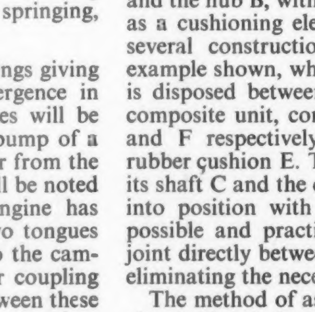
In practice many components require couplings giving complete rotational slip, hence a great divergence in design and construction of cushioning devices will be observed. As an example, the fuel injection pump of a compression ignition engine is driven by a gear from the engine. This is illustrated in Fig. 1, where it will be noted that a gear and shaft A driven from the engine has splined to it a coupling disc B, which has two tongues formed upon its outer rim. Similarly keyed to the camshaft E of the fuel injection pump is another coupling disc C, also constructed with two tongues. Between these two discs are placed the coupling rings D, having four slots machined in it to accommodate the tongues of the two coupling discs B and C.

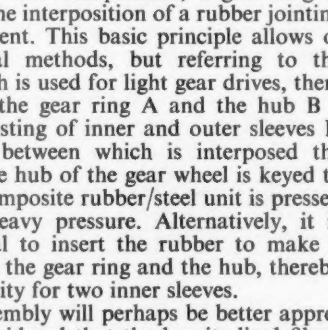
The camshaft of a fuel injection pump is a very hard working component, designed to withstand the very heavy operating pressures and both torsional and bending effects. Experience has shown that the type of drive illustrated is highly suitable for the particular purpose, the coupling ring being of woven cotton or nylon impregnated with plastic or synthetic rubber heated and compressed to approximately a third of its original thickness. The degree of flexibility obtained is ideal for fuel pump transmission and the coupling stands up well to fatigue caused by pulsation of the pump while also providing for the minute angular deflexion so essential and allowing for the small but desirable transverse misalignment between the connected shafts of up to 0·05 in.

Where longitudinal shaft deviation is not envisaged, infinitesimal angular deflexion can often be efficiently dealt with in gear drives by installing a gear wheel made of similar materials to those enumerated previously, but if a more enhanced flexibility is necessary this may be obtained by instituting an arrangement similar to that illustrated in Fig. 2. Here it will be seen that the gear wheel is formed into two components, a gear ring A and the hub B, with the interposition of a rubber jointing as a cushioning element. This basic principle allows of several constructional methods, but referring to the example shown, which is used for light gear drives, there is disposed between the gear ring A and the hub B a composite unit, consisting of inner and outer sleeves D and F respectively, between which is interposed the rubber cushion E. The hub of the gear wheel is keyed to its shaft C and the composite rubber/steel unit is pressed into position with heavy pressure. Alternatively, it is possible and practical to insert the rubber to make a joint directly between the gear ring and the hub, thereby eliminating the necessity for two inner sleeves.

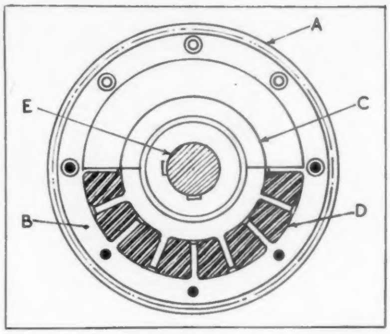
The method of assembly will perhaps be better appreciated when it is considered that the longitudinal fibres

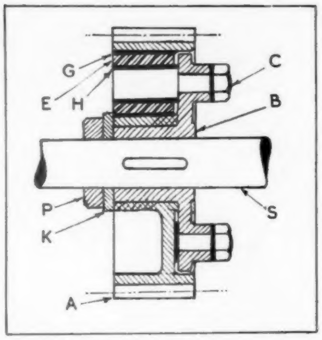


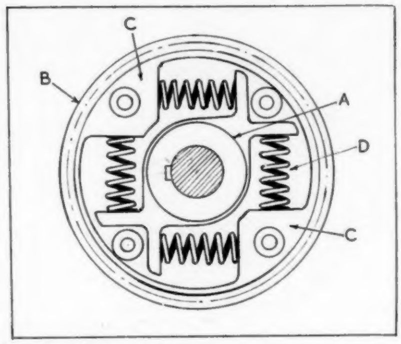




Flexible gear drives for: fuel pump (Fig. 1 above); power press (Fig. 2 centre); textile machines (Fig. 3 right)







Flexible gear drives for: rock crusher (Fig. 4 left); line shafts (Fig. 5 centre); heavy oil engine (Fig. 6 right)

of the elastic ring are stretched, and when in position between the inner and outer surfaces, the effort made by the ring to re-establish its original shape exerts a radial compressive force of such intensity that no slip can take place between the two components.

The design of the drive ultimately depends not only on the torque to be transmitted but also upon the degree of flexure determined from actual operation, and frequently the atmospheric conditions. Constructions such as those described have been successfully applied to power presses, absorbing the shocks and cushioning the intermittent loads to which this class of machine is subjected: not only so, but the durability of the driving gear has shown improvement of as much as 400%.

The special advantage of rubber cushioning is the ability to deal with torsional and longitudinal deflection singly or in combination. Where somewhat heavier duty power transmission is involved, and where it is desirable to incorporate the advantages of rubber as the resilient medium, more robust constructions become essential. One such is illustrated in Fig. 3. Here a toothed gear ring has two flanges A, and two hubs B, keyed to the gearshaft C. Synthetic rubber rings E are welded to the metal components in a pre-load condition.

Variations of flexure are easily attainable in either natural or synthetic rubbers, but the latter have advantages in that they are impervious to humidity, oils, spirits, acids, and high and low temperatures within wide limits. Such gear drives have in practice proved highly satisfactory on certain textile machinery where a continuously efficient performance at high rotational speed and rates of flexure are involved. The example shown permits any reasonable misalignment and eccentricity, while cushioning the machinery against overloads, vibration and shock. It is equally satisfactory in either direction of rotation, while its extreme simplicity assures great durability.

Coming now to gear drives where duties are heavy, and again wishing to retain the favourable conditions appertaining to the embodiment of rubber, the assembly illustrated in Fig. 4 is of interest. Here a resilient gear wheel is based on the employment of rubber blocks in compression between the blades of a driving and driven member. The construction comprises five distinct parts, and in the figure it will be noted that a large gear A has a series of internal blades B, while a hub member C formed with external blades D is keyed to the shaft E. Successively between the two sets of blades, rubber blocks F, which are initially in compression during assembly, are inserted. This initial compression is to preclude complete unloading under the most severe torque conditions, while ensuring that full resilience is available at all times. An important feature of this particular construction is the adoption of a maximum volume of rubber, which allows of very high shock absorption and damping so desirable in colliery work, rolling mills and rock crushers.

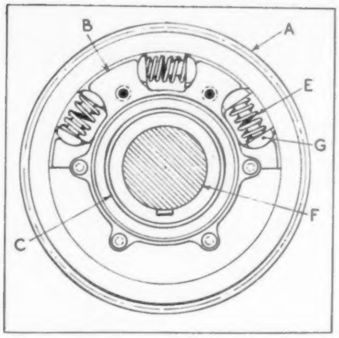
There are of course many other types of resilient gear drive based on the inclusion of rubber as the cushioning medium, and in some instances, while flexibility is desirable, an essential feature is that the whole may be quickly and easily demountable. In Fig. 5 is illustrated a construction of this kind occasionally used for line shafting and special machine assemblies. It will be evident that it fulfils the requirements for it is in effect a pin type coupling and gear wheel combined. The gear wheel A is a solid element formed with a central bearing machined and fitted to be capable of part rotation around the hub of the driven flanged member B. This latter is mounted by keys on the shaft S and carries a series of pins C, the larger portions of which are located in pre-loaded rubber bearing components having inner and outer sleeves G and H. These rubber bearings are assembled into bores machined in the gear wheel A and are maintained in position with the flange member by a collar K and a nut P screwed on to the driven shaft S.

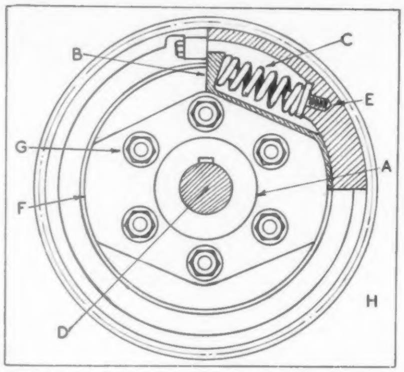
It will be evident that while torsional flexibility is catered for, no longitudinal deviation has been considered in this particular design, nevertheless this construction has proved very satisfactory in practice, being noiseless in action and requiring a minimum of maintenance.

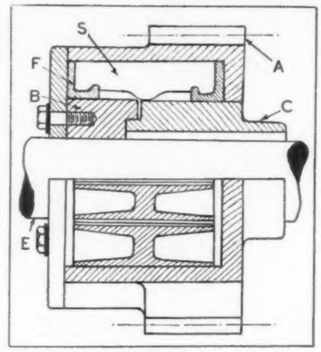
Flexibility, load carrying capacity, vibration and damping are all calculable so that practically any desired result is attainable. Hence by reason of general simplicity, it is obvious that rubber type flexible bearings are likely to play a greater part in the future development of cushioned gear drives.

Certain industrial conditions such as very high power gear transmission, excessive maximum or minimum temperatures, humidity, salt water and certain alkalis may preclude the use of rubber or plastic cushioning devices, and definitely render necessary the use of all-metallic gear drives embodying flexibility. The absorption of shock in the transmission of power to reciprocating pumps, air compressors, shearing machines, planing and shaping machines, turbine gearing, etc., is often most important for durability.

The degree of flexibility to be embodied will more or less decide the design of the drive, and in machinery or plant where divergencies in loading are strictly limited it is often possible to obtain the required resilience merely







Flexible gear drives for: locomotives (Fig. 7 above); reciprocating pump (Fig. 8 centre); heavy machinery (Fig. 9 right)

by equipping the installation with a driving pinion of rawhide or compressed paper, fabric, or phenolic resin, all of which will institute some degree of cushioning.

To ensure definite slip it is sometimes advisable to introduce a clutch in the drive, using friction, hydraulic or electro-magnetic devices, but this is largely influenced by special requirements.

In general it is highly desirable to embody the cushioning elements as far as possible within the dimensions of the driving pinion or gear wheel. In Fig. 6 is illustrated such an assembly comprising an element A keyed to the driving shaft in the usual manner, which has mounted upon it a gear wheel B. Lugs C are formed integrally with the internal diameter of the gear wheel and also on the hub member, while disposed between them is a series of helical springs D through which the load must always be transmitted in either direction of rotation. Completing the assembly is a cover plate to render it dust proof. This is a very substantial construction used in various industrial gear drives and is obviously ideally suited to dealing with heavy and fluctuating loads.

Another gear drive which differs considerably from the preceding example, except that the cushioning effect is again taken through coil springs, has proved very satisfactory over years of service in divergent applications. It is illustrated in Fig. 7 and it will be seen that it consists of a gear ring A on the internal surface of which are formed four short arms B, the gear ring being mounted to run freely on the steel hub C, which is also furnished with four projecting arms. These latter are provided with sufficient clearance to accommodate the projecting arms B, although the only connection between these sets of arms is through the heavy helical springs E by which means power is transmitted from the gear to the hub fixed to the shaft F. Ball headed pins G are fitted at the ends of the springs to ensure correct positioning on the arms. Cover plates bolted to the hub afford protection to the interior against foreign matter, the whole forming a compact assembly.

Coming now to the flexibility of exceedingly heavy gear drives, it is difficult to construct cushioning devices capable of being completely contained within the normal width of the gear, hence the general design will more or less be dictated by the space available. In Fig. 8 is illustrated a cushioned drive assembly for a very heavy duty reciprocating pump, and in this particular instance the resilient gear is of the split rim type of construction. This drive might well be adapted to air compressors, metal planers and shapers, and punching and shearing machinery, though it is not used to any great extent for such purposes, no doubt because of the additional expense.

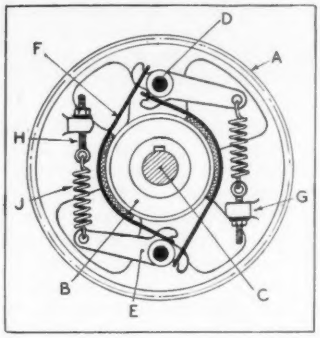
In the figure it will be noted that helical compression springs C, arranged for shock absorption, are disposed side by side, that is in duplicate, on one central hub member A keyed to the driven shaft D. The hub has a series of abutments B, while a similar number of stud abutments E are fitted on the interior of the gear wheel H, the compression springs C being located between them. In such gear drives the springs are generally designed for loads of five times the normal gear load. End covers F, held by studs G, complete the assembly.

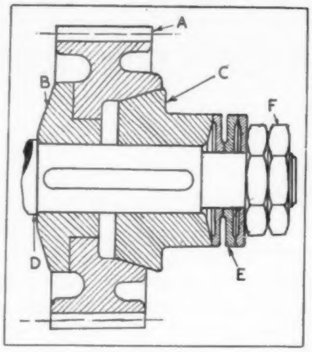
It will be apparent that torsional flexibility can be adequately provided, but that transverse deviation is not so easily dealt with, and in heavy duty assemblies is more or less ignored. For this reason many industrial gear drives are designed in conjunction with flexible shaft couplings, but such assemblies are largely dependent of space. Fig. 9 illustrates such a design, wherein a toothed gear A is fitted with a component carrier B in which are located a series of special plate springs S. The hub C is keyed to the driven shaft E, and is also provided with a number of slots to take the ends of the plate springs. There is no connection between the driving and driven members A and C except through the plate springs, these being further supported by the end rings F. The locating arrangement is such that the end rings float in the interior of the gear and are capable of rotary movement about the hub axis.

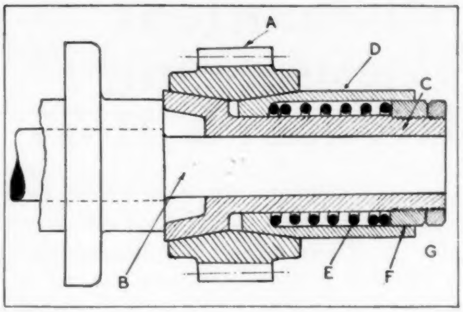
Important advantages accrue to this construction in that a wide variation in the degree of flexibility is obtainable by changing the number and gauge of the plate springs, which enables the torsional stiffness to be varied without in any way impairing the required ultimate strength of the drive. In the design of such components for heavy intermittent and irregular loading the spring force is usually based on two or three times the actual gear tooth load.

As mentioned, it is often desirable that the cushioning of a gear drive may be effected by spring controlled friction to deal with shock or overload. Such devices can be comparatively simple, but if subject to shaft misalignment it is essential to make special arrangement, often culminating in the adoption of a flexible shaft coupling. The writer has often overcome this problem of alignment by fitting some form of self-aligning bearing between the hub and the gear.

Where gear drives are employed for looms with fixed reeds, some flexibility *via* slip is very necessary. In Fig. 10 is illustrated a construction which has been found very satisfactory for the purpose over a number of years. As







Flexible gear drives for : looms (Fig. 10 left); jig crane (Fig. 11 centre); machine tools (Fig. 12 above)

will be seen it is incorporated in the gear wheel which has two parts, an outer toothed ring A which is free on the hub of an inner brake drum B keyed to the shaft C. The flange of the gear wheel carries two pins D on which are mounted two levers E having ears which carry the ends of brake straps F lined with friction material to operate on the brake drum B. The gear wheel flange also carries two lugs G to which are fastened screwed hooks H, which latter are connected to tension springs J mounted on the ends of levers E.

The tension on the brake bands may be regulated through the springs and is so adjusted that the maximum starting torque is transmitted without slip, but if the loom to which the shaft is connected is suddenly stopped, slip between the drum and the brake band occurs, thus reducing the shock on the gear teeth.

When it is necessary to protect an electric motor a spring will act as a safety device. This is particularly the case on motor-driven jig cranes, and one such device as fitted by a well-known manufacturer is shown in Fig. 11. Here a gear A meshing directly with the motor pinion is mounted upon the flanged hub B and a bronze cone C, both of which are keyed to the driven shaft D. By means of the three tempered steel Belleville type springs E and the two adjusting nuts F, the desired axial force may be transmitted to the clutch members B and C. The combination A, B, C amounts to a conical slip clutch. The angle that the element of the cone makes with the axis 50°. The assembly gives a desired torsional flexibility for starting a motor drive and has proved very efficient mechanism for the purpose.

A final construction on similar lines adopted for machine tool drives is illustrated in Fig. 12. As utilized on a table feed mechanism its function is to permit the pinion A to slip when the load on the cutter becomes excessive. The driving shaft B has keyed to it a bronze sleeve C on which is slidably mounted another sleeve D. It will be seen that parts of the sleeves are made conical to fit the conical bore of the pinion A. The frictional force required to operate the table is obtained by the pressure of the spring E inside the sleeve D. By means of the adjusting nuts F and G the spring pressure may be varied to suit any particular operating conditions.

It will be apparent that in this and similar devices where due regard has been given to torsional flexibility, little attention is paid to misalignment, but it will be appreciated that this may be infinitely small and be covered by tooth clearance in the gears.

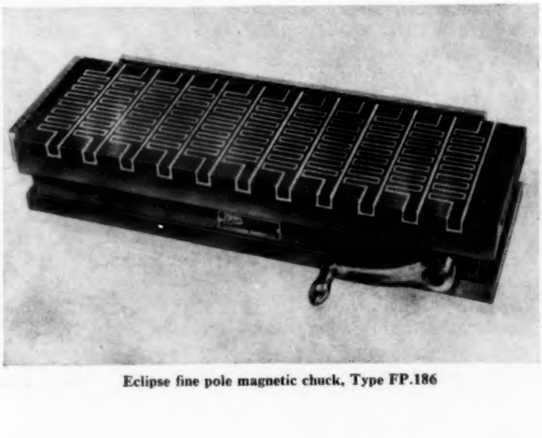
In conclusion, the attention of designers is drawn to the variations in type and style of cushioned gear drives as outlined herein, and to the ever-increasing demand for new ideas in this field. It would appear that rubber will play an important part in the future where drives not only require flexibility, but also are to negate various forms of misalignment. It is also possible that a combination of rubber and metal constructions may prove most effective where extreme temperature conditions do not prevail, while being capable of meeting heavy loading together with silent operation, durability and minimum maintenance.

Linked Poles Concentrate Magnetic Chuck Gripping

To meet the demand for fine pole magnetic chucks, particularly when associated with production grinding machines, where maximum table loading of relatively small components is required, James Neill & Company (Sheffield) Limited, Napier Street, Sheffield 11, is introducing a range of fine pole permanent magnet chucks, with high effective magnetic area on their workholding surfaces.

The first model to be announced is Type FP. 186, having a working surface of 18 × 6 in. Similar chucks will shortly be available for table sizes of 24 × 8 in. as well as for 10 and 12 in. wide tables in any multiple lengths of 18 in.

An inspection of the new type chuck will show that the 'inner' poles extend from edge to edge with a castellated arrangement of the poles providing the major holding area in the centre. By an ingenious method of pole construction, the 'outer' poles are linked together thus enabling magnetic flux from all magnets to be fed to a single workpiece placed anywhere on the chuck surface.



Eclipse fine pole magnetic chuck, Type FP.186

Mechanical Engineering Research 1957

Notes on work in hand or projected at the East Kilbride Laboratory

SINCE our last review of the work of the Mechanical Engineering Research Laboratory at East Kilbride, Glasgow, two new buildings have been completed, the metrology building and the heat building. The former provides outstanding facilities for making accurate engineering measurements, for research on noise control, mechanisms and power transmissions, and for the development of novel types of instrument for precision measurement. The heat building provides the special facilities, such as steam at various pressures, cooling water and electrical services, needed for the provision of accurate basic data for the design of conventional and novel types of heat exhanger. This building will house the DEUCE digital computor, an early use for which will be the preparation of tables of thermodynamic properties of industrially important fluids.

Among the year's work the Materials Division has completed tests which show that Unified Fine Series (UNF) threads should not normally be used for general engineering purposes where heavy loads have to be transmitted. This is not due to any defect in the Unified thread form but rather to the fineness of the series. For most practical applications the Unified Coarse Series (UNC) should be suitable. When UNF threads have to be used for such purposes, the tightening must be carefully controlled.

An important investigation by the Fluids Division aims at providing basic data for the design of oil-hydraulic relief valves—an electrical analogy method is giving promising results. Measurement of the transient pressure characteristics of eight commercial valves has shown that their characteristics varied widely and that none was satisfactory in all respects. An important finding was that the circuit in which the valve is being used has a marked effect on its characteristics. For instance, they will change with the lengths of the pipes between it and the pump and between the relief valve and the valve causing the pressure rise.

Fretting corrosion is a form of wear which takes place when there is very small, but repeated, movement between two surfaces in contact. Investigations have shown that under dry conditions the harder cast irons wear much less than the softer ones—but there was relatively little difference between hard and soft materials when oil or grease lubricants were used. The phosphorus content was found to be very important with annealed specimens. These tests by the Lubrication Division suggest that the initiation of serious wear in cast-iron machine-tool slides probably takes place when the slides are inadequately lubricated and subjected to fretting conditions.

The Metrology Division has begun research into noise-control and investigations are now taking place in a new anechoic chamber—a room in which the walls, ceiling and floor are completely lined with glass fibre wedges to absorb sound. In progress at the moment is an investigation of the noise-generating properties of commercial ball-bearings, to determine which types of inaccuracy in manufacture or method of mounting are chiefly responsible.

When a single crystal of uranium is irradiated with neutrons it grows along one axis and shrinks along another. In a uranium fuel rod in a nuclear-energy reactor the individual crystals cannot deform freely; internal stresses are set up which could have serious consequences if they were not fully taken into account at the design stage. A theoretical investigation of the problem by the Plasticity Division has given an understanding of the mechanism by which neutron irradiation leads to greatly accelerated creep deformation in uranium.

The Heat Division now has special facilities for research on basic and applied heat transfer on a substantial scale. It hopes to prove that dropwise condensation can be considered sufficiently reliable for designs to be based on it. This would involve determining in detail, by trials of full-scale plant, what changes were justified in the size and construction of heat-exchangers.

In the annual report* the Mechanical Engineering Research Board write: "In the decade since the Laboratory was founded spectacular industrial developments, some of them in new fields, have underlined the need for intensive research on a much larger scale if Britain is to keep her place in the world." The report gives examples of the kind of research which the board see as urgently needed to assist outstanding industrial developments.

One of these is high pressure research which would lead to new knowledge of the physical properties of existing materials and, in conjunction with high temperatures, the production of entirely new materials by changing crystal structures.

Already synthetic industrial diamonds and a nitride of boron harder than diamond have been produced in America. Another use of very high pressure is in forming certain brittle materials which cannot be formed at atmospheric pressure. An outstanding example is the manufacture of beryllium sheaths to contain the fuel elements of nuclear reactors.

Another desirable line of enquiry concerns pumps. If pumps were run at much higher speeds their size for a given duty could be reduced. An investigation of the theory of blade design must have high priority. Pumped storage for hydro-electric schemes, particularly when used in conjunction with nuclear plants, is gaining in importance. When the turbine is used in reverse as a pump, problems arise for which solutions are urgently required.

The effects of irradiation demand attention. Nuclear reactors use niobium, tantalum, zirconium and beryllium which previously had few industrial applications. A knowledge of their properties and how these are affected by irradiation is vital for successful design.

Developments are taking place in heat exchangers and if the heat-transfer rate of air-cooled condensers could be sufficiently increased they might replace water-cooled condensers with great simplification of design and operation. Rotary heat-exchangers have great possibilities.

* Mechanical Engineering Research 1957, the Annual Report of the Mechanical Engineering Research Laboratory at East Kilbride, near Glasgow. H.M.S.O. price 4s. 6d. (81 cents U.S.A.) by post 4s. 10d.

Recent Research into Stainless Steels

Stainless steels are playing an increasingly important part in every walk of life, from industry to nuclear fission and the minor aspects of domesticity. They have infiltrated into architecture, shop design, the food and agricultural industries, into naval and military matters and rocket design. In consequence, continuous research is going on with a view to their improvement. Some account is given of recent investigations

THE sigma phase in austenitic stainless steels has had much attention over the last twenty years. It is a hard, brittle compound originally believed to be the simple compound FeCr, but now known to embody other elements, since atoms of either iron or chromium may be replaced by atoms of alternative elements. It is often the cause of severe embrittlement of the steel, especially if it has been exposed for a considerable period to a particular temperature range.

It had been perceived for some time that cold working of the highly stable austenitic stainless steels caused an acceleration of the rate at which the sigma phase formed, and a series of researches was put in hand so that the influence of cold work might be more clearly grasped. The stainless steels forming the subject of the research were those that do not form ferrite when cold worked. It was found that before any marked increase in the rate of sigma formation in these steels occurred, it was necessary that the amount of cold working should be sufficient to cause recrystallization of the steel. A less degree of cold working failed to produce any acceleration of sigma formation, or at all events, only a negligible effect. In fact, small amounts of cold working actually delayed the formation of sigma in some annealed stainless steels at particular ageing temperatures. In short, cold working does not in itself develop a larger number of nuclei of sigma which increase in size after recrystallization, as was at first supposed. Instead, it is the recrystallization that by itself accelerates sigma formation.

One of the desires of the engineer concerned with design and of the metallurgist is for a stainless steel that can be age-hardened or precipitation-hardened. Such a steel would have to be of ferritic type, and preferably of 12% chromium content. It is possible that attempts have been made in the past to produce such an alloy, but if so, the work has largely been carried out under conditions of secrecy, and little is known of the results. Recently, however, a series of experiments has been devoted to determining whether a range of alloys of 12% chromium type could be given precipitation-hardening properties by the addition of titanium. The alloy contained 4% molybdenum in addition to the chromium content. Various amounts of titanium were used.

The investigations were extremely technical, concerned rather with the presence or absence of particular phases known to promote precipitation than with practical matters, but a brief summary is that an increase in the titanium content of the alloy under the conditions of the experiments promotes the formation of a 'Chi' phase which facilitates precipitation, gives good high temperature properties and has ductility at elevated temperatures, while being quite brittle at room temperature.

The world shortage of nickel caused largely by its increasing use in the manufacture of military weapons and in industry generally has reawakened interest in the austenitic chromium manganese nickel stainless steels, first developed in the pre-Hitler years by Russia and Germany, which were short of nickel. The introduction of nitrogen into these steels was attempted not only to conserve nickel, but also to increase their applicability. Not enough was known, however, regarding their properties when alloyed with nitrogen, and therefore an extensive investigation was put in hand a few years ago, the results of which are now available. The idea was to study the structure and mechanical properties of a range of steels containing 12 to 18% chromium, 1 to 20% maganese, 0 to 14% nickel, and 0·06 to 0·12% carbon, with nitrogen contents between 0·03 and 0·18%. It was already known that nitrogen made such steels more easily hot-worked, but less was known about other properties.

It was discovered that steels with 16 to 17·5% chromium, 3·5 to 4·5%, 7 to 9% manganese, 0·06 to 0·12% carbon and 0·12 to 0·18% nitrogen possess a high degree of the desirable stability of the austenite, while the mechanical properties and work-hardening properties of these steels can be compared to those of the austenitic 18–8 chromium nickel stainless steels. Ingots of these steels if of considerable size will show excellent hot working properties when their initial hot working temperature is maintained at a maximum of 1225° C.

Austenitic nickel chromium 18–8 stainless steels at room temperature are not usually austenitic, but it is possible to transform a part of the austenite into martensite by plastic deformation, given proper conditions of temperature and strain. There was much uncertainty regarding the properties of this martensitic transformation in highly pure 18–8 steels transforming spontaneously on cooling, and regarding the influence of plastic deformation on the transformation in these alloys both during deformation and during later cooling to room temperatures. Consequently, these matters were investigated.

It was found that the temperature at which the transformation of austenite to martensite takes place during

cooling falls sharply as carbon content increases, while the isothermal transformation of martensite is observed on holding at temperatures below zero. The quantity of martensite developed by plastic tensile strain increases as the deformation temperature declines. Small amounts of plastic strain in the austenite promote the later transformation during cooling, especially after elongations of from 2 to 4%. Mechanical stabilization of the austenite, or even total suppression of the martensitic transformation during cooling, can be effected by plastic strains of greater magnitude.

Stress corrosion cracking results from the combined effects of corrosion and stess. Many metals and alloys are liable to this, and the stress most often causing this type of failure is usually developed by cold forming, welding or other operations, though external tensile stresses may also cause such failures. It was felt that research should be undertaken with a view to discovering precisely how cracks in stressed martensitic stainless steels were caused when these steels were immersed in various types of corrosive agencies. Moreover, the influence of tempering temperature on the liability of 12% chromium stainless steels to fail under relatively mild corrosive conditions needed to be studied in detail, in the belief that this would facilitate understanding of the mechanism of cracking in these conditions.

The data provided by the research suggest that tempering in the region of 260° C renders these steels less susceptible to cracking by hydrogen embrittlement for high levels of hardness. The greatest liability to stress corrosion cracking and hydrogen embrittlement is found if the steels are tempered within the temperature range 430° to 540° C. A type of ferrite known as 'delta ferrite' reduces the degree of cracking caused by stress corrosion when present in the steel, because it reduces the range of tempering temperatures that cause stress cracking, and also impedes the formation of cracks. It must be pointed out, however, that many authorities are not convinced that the research entirely eliminates the possibility that hydrogen freed by corrosion may contribute to the failure of these steels by cracking. There is also the possibility that while delta ferrite reduces cracking when the stress is applied in a direction transverse to the grain flow, it may not be effective in this way when applied in a direction parallel to the grain flow. It is felt that more work has yet to be done before stress corrosion cracking of these steels and its mechanism are fully comprehended.

A series of fully austenitic stainless steels having distinctive properties, but based on the iron-chromium-carbon nitrogen system, has recently been introduced. The effect of introducing nitrogen into these normally ferritic alloys is to render them, assuming the chromium content to exceed 22%, partly austenitic. It has now been established that if these 22% (or over) chromium alloys contain up to 1% of carbon, there is a considerable increase in the quantity of nitrogen that can be retained. The result is that the steels become fully austenitic. The maximum chromium content must be 33%, and the temperatures necessary are about 1200° C or above.

The austenite in these steels is prevented from decomposition into ferrite, carbides and nitrides by rapid cooling to room temperature. The greater the chromium content, the higher must be the carbon and nitrogen contents if the structure is to be fully austenitic. The steels when austenitic are said to work harden to a considerable degree and to have high tensile and yield strengths.

The 12% chromium steels, to which reference has earlier been made, are martensitic in type, and although less resistant to corrosion than the austenitic stainless steels, have at all events a sufficient degree of resistance to render them suitable for many applications where an 18–8 stainless steel would be too expensive. They also have the advantage that they can be heat-treated to a high degree of hardness, while tempering to provide a wide range of strength and ductility is also possible.

One of the limiting factors of these steels is their lack of ductility, which renders them liable to fracture and consequent failure. The factors affecting their resistance to brittle fracture have been studied, and it has been found that adding about 0·7% molybdenum and nickel and reducing the silicon content to about 0·5% produces a steel much more resistant to brittle fracture at winter (sub-zero) temperatures. One important point that has been satisfactorily established is that notches such as sharp fillets, threads, nicks, fatigue cracks, weld flows, etc., greatly contribute to the brittleness of these steels, which may even show quite high ductility when notches are completely absent.

The influence of composition on the 12% chromium stainless steels when embrittled at a temperature of about 470° C has not been fully determined, and for this reason an investigation was initiated into the influence of alloying elements on embrittling behaviour, the basis chosen for the investigation being a study of impact properties. The effect of differing carbon, chromium, molybdenum, aluminium and titanium contents of the steels when aged for 10,000 hr at 480° C was determined. It was found that a carbon content increased to 0·08% developed somewhat lower transition temperatures in the annealed condition, but an increase in transition temperature for all combinations of chromium and carbon contents was observed after ageing. A content of 0·25% aluminium had no effect on this temperature, but 0·5% molybdenum reduced the temperature increase. Molybdenum and aluminium combined seemed to eliminate the transition temperature completely.

Advantages arising from cold or hot working of steels as regards their low-temperature and high-temperature properties are well known, but what is not known is the comparative advantages of different compositions of stainless steel for strengthening by cold or hot working. Static recrystallization tests and tests of creep-rupture have been carried out, therefore, on an 18–8 columbium-stabilized stainless steel, solution treated and cold worked.

The results showed that recrystallization takes place up to 100° C lower during creep-rupture than in static tests. Useful high temperature strengthening in creep-rupture is obtainable by cold work or warm work. Thus, up to 30% cold reduction shows improvement at 650° C up to at least 1000 hr, up to 10% cold reduction a 1000 hr life at 700° C and over 30% a 1 hr life or less. Up to 20% cold reduction gives a 1hr life at 820° C, but cold work should be avoided for rupture lives of more than about 1 hr (the solution treated condition is best). At 590° C and below, considerable improvement can be obtained for long time use with cold work up to 30% or more.

Pneumatic Circuits

Layouts and the application of valves, cylinders, fittings, etc.

THE details of valve and cylinder design, the advantages of unit construction with particular reference to valves and basic information in tabular form relating to applied force and air consumption of cylinders were dealt with in an article in MECHANICAL WORLD for February, 1958. The present article deals with pneumatic circuits, mostly of a simple nature, which illustrate in some measure the application of such valves, cylinders, etc. All the circuits are in diagrammatic form and in no instance is there denoted any means of air line lubrication or filtration although it must be taken for granted that in most cases this is necessary. Every valve referred to in the circuit diagrams is of the unit construction type (i.e. consists of basic units assembled in different ways to give a large variety of valves by virtue of the many possible combinations). Where single acting cylinder operation is necessary one of the outlet ports must be blanked off.

Hand-operated direct-acting valves

Such valves, provided the application is considered satisfactory may be used in pipe sizes up to and including $\frac{1}{2}$ in. B.S.P. Size for size, hand-operated valves may look identical, but they may work in different ways, and this point was referred to in the previous article. Referring to Fig. 1, for instance, the hand valve could be either positive or spring return, and obviously would have to suit the application, i.e. whether sustained 'on' and 'off' positions are required or otherwise.

Fig. 2 shows a double-acting cylinder being controlled by a hand valve which could either be positive or spring return, or alternatively either self-exhausting or self-sustaining (the hand lever being inoperative in the central position). The action of positive and spring return types of valve are self-explanatory but confusion often exists regarding self-exhausting and self-sustaining types due, most probably, to the use of other nomenclature. Both have the handle spring loaded to the central position. With self-exhausting valves both cylinder ports are open to exhaust before the valve is operated. Self-sustaining valves differ in this respect because in the inoperative position both cylinder ports are sealed off from exhaust. Hence such a valve is often referred to as a hoist valve because it is ideally suited for use with air hoists where it is necessary to sustain or move the load with great ease of manipulation.

Fig. 3 shows a simple method of using compressed air to operate a sliding rheostat unit, and it is obvious in this case that a positive type of valve would be used. The flow control valves are used to govern the upward and downward speed of the rheostat and are of the type that, once set, the spindle may be locked in that position and will not move against vibration. The example shown is a hypothetical consideration since a hand valve is hardly likely to be used in this case except for perhaps remote control, the more likely application being an automatic valve, pilot-operated from a guard or some other source of safety interlock. Nevertheless, compressed air can be, and is, used for such a purpose provided great care is exercised in setting the flow valves.

The use of the small pneumatic press for light engineering production is widespread today and in such cases guarding must obviously be effective and a pneumatically-operated interlocked guard is very often found to be the answer. Fig. 4 showing in diagrammatic form this system introduces a Midland Pneumatic positive hand valve B which, when guard D is in the 'down' position, will function in the normal manner

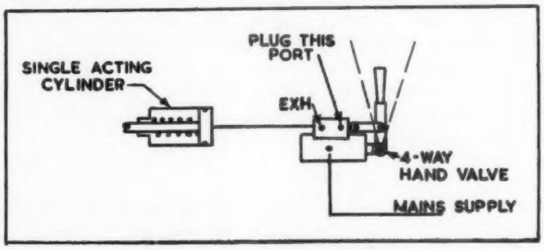


Fig. 1.—Valve and single-acting cylinder

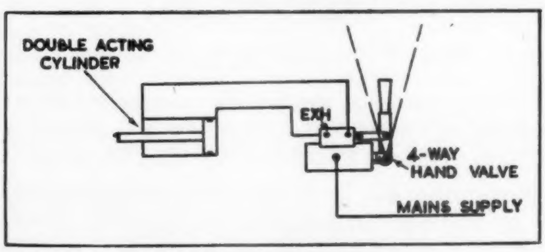


Fig. 2.—Valve and double-acting cylinder

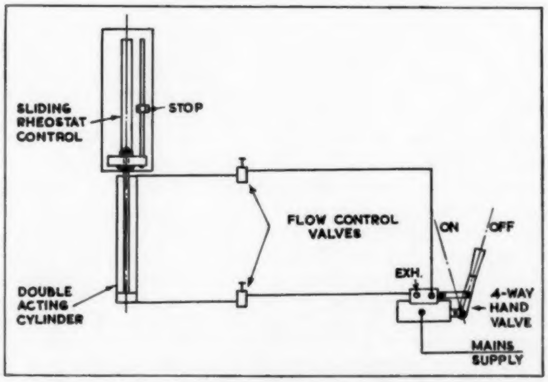


Fig. 3.—Valve and double-acting cylinder for control of sliding rheostat

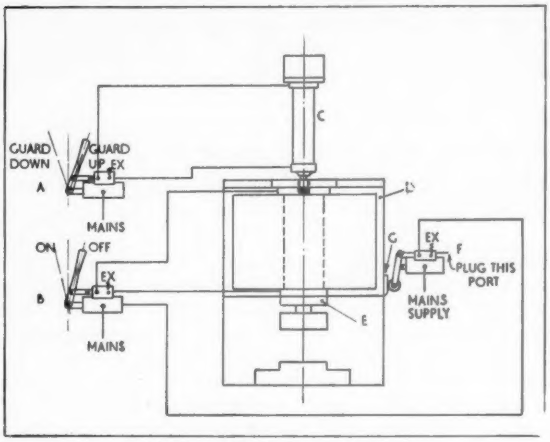


Fig. 4.—Air interlock on guard system

and operate cylinder E which virtually is the press. However, when hand valve A is operated to bring the guard into the 'up' position via cylinder C, ramp G affixed to the guard will trip lever- and roller-operated valve F. This puts an air supply on to the pilot port of valve B, thus returning it to the 'off' position. Furthermore, it will stay locked against any hand operation until guard D descends into the safe position. This feature of having a pilot port in valve B for pneumatically returning and sustaining in the 'off' position is exceptionally useful on interlocking systems, and has a wide application in circuits of this nature. Apart from this, however, valves A and B are identical in design.

Electro-magnetic air valves

With everyday tendencies towards automation the scope of the electro-magnetic valve is increasing. Linked up with the electrical circuit, immediate and accurate response in operation is obtained. Therefore, for synchronization problems, batching and predetermined counting, etc., or where remote control or electrical interlocks may be necessary, the electro-magnetic air valve is found to be almost indispensable. The operating coil of such a valve may be to suit either a.c. or d.c., and where a low voltage d.c. coil is required to operate from a.c. mains a rectifier is supplied for this purpose.

Figs. 5, 6 and 7 serve to illustrate the two main types of electro-magnetic valve, perhaps more popularly referred to as solenoid valves, and the various ways in which such a valve may be used.

Fig. 5 shows a double-acting cylinder controlled by two solenoid operated, spring return, valves via flow control valves. Each solenoid valve has one cylinder port plugged up, thereby operating as a three-way valve.

This method of operation is well suited for slow moving piston rods which must be halted and then re-started at various points during the upstroke and downstroke. Valve B operates cylinder A in one direction through flow valve G (note: flow valves should wherever possible control on the exhaust side) merely by depression of start button D. The piston rod movement may therefore be halted or re-started by depression and release of button D. Similarly button E operates valve C which in turn operates cylinder A via flow valve F.

In Fig. 6 exactly the same type of valve is used as in the former example but in this case the valve is

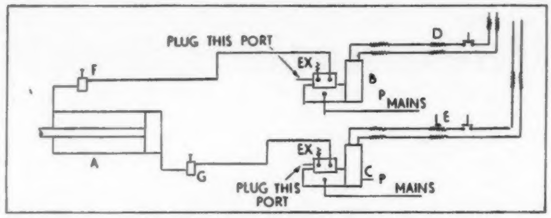


Fig. 5.—Independent single solenoid valve control

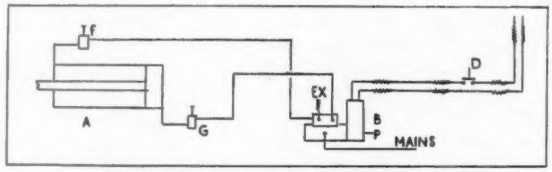


Fig. 6.—Single solenoid valve giving bi-directional control

used as a *four way* valve, both ports being connected to this cylinder. Therefore from valve B, air at pressure is permanently on one side of the piston in cylinder A with valve B being de-energized at the solenoid. By depressing button D and thus energizing valve B, air is exhausted from the one side of the piston and transferred to the other side. Flow valves F and G govern piston rod speed in each direction. From this explanation, however, it will be realised that in such circumstances there is no mid- or other intermediate piston position. Furthermore, releasing start button D before the piston rod has completed its full stroke would merely reverse the piston rod. It may also be added that the solenoid in valve B is energized in alternate cycles and from this point of view, duration of cycle and rating of solenoid must be borne in mind.

As illustrated in Fig. 7, valve B is a double solenoid impulse operated type. Wherever its use is possible this is undoubtedly the best type of solenoid valve to employ. Although more costly than the single type it is self-sustaining should the electrical supply fail, because each solenoid is only momentarily energized to reverse the valve; furthermore, because of this the coil life is greatly increased. With a single solenoid

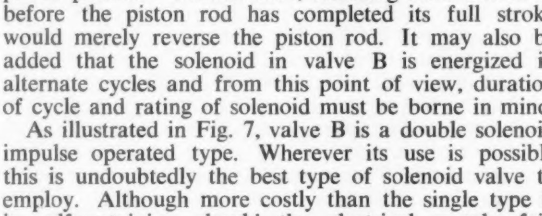


Fig. 7.—Double solenoid valve (impulse-operated) giving bi-directional control. Note: P pilot port for use when necessary

valve, should the electrical supply be left on during a 'live' cycle, which is quite possible with certain cycling arrangements, the solenoid is energized all the time and this is not very good for the coil. A double solenoid valve cannot fall victim to any of these circumstances.

Returning to Fig. 7; a momentary depression of either button D or button E will operate the respective solenoid and reverse the valve B, which in turn, reverses cylinder A, speed control in either direction being governed by

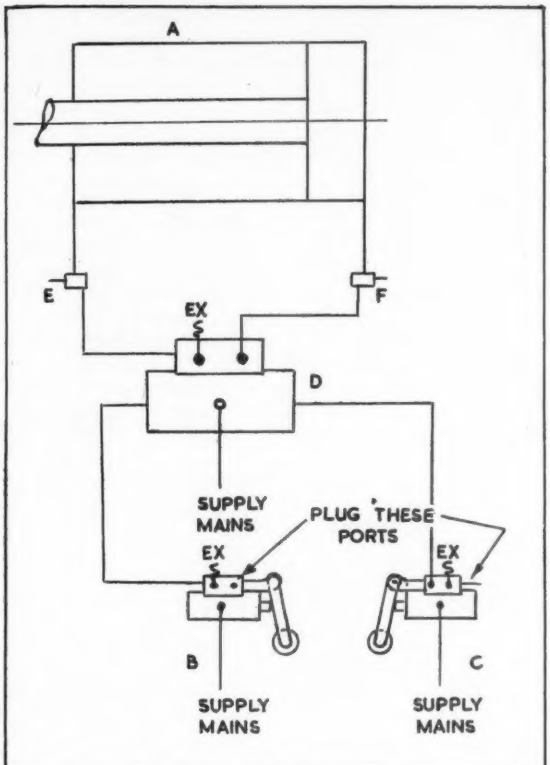


Fig. 8.—Cam operated pilot valve servo system

flow valves F and G. The valves illustrated in Figs. 5, 6 and 7 are of the Midland Pneumatic type and in each case a pilot port is shown which may be used if desired. All these valves have built-in piloting and therefore, under normal circumstances, there is only one connexion to the valve from the mains supply. But if, on the other hand, high pressures are to be used, say up to 350 psi, then the pilot port or ports may be branched from the main and, with the insertion of a reducing valve in the branch feed, a lower pressure (up to 100 psi) used for pilot purposes. Indeed, such measures would be necessary since the spring used to hold down the solenoid core on the pilot seat would not oppose air at higher pressures. This complete range of valves varies in size from $\frac{1}{8}$ in. B.S.P. up to 1 in. B.S.P.

Pilot or servo-valve operation

Users of pneumatic equipment often want to know where pilot or servo operation is either beneficial or necessary. No single answer would give general coverage to this particular question, but some information which should prove helpful is given hereunder.

Objects of pilot or servo-valves

1. To pilot-operate larger valves which when directly operated require a fair amount of manual effort.
2. To place a valve close to the cylinder it operates (for fast response and sensitivity) with controls at a distance.

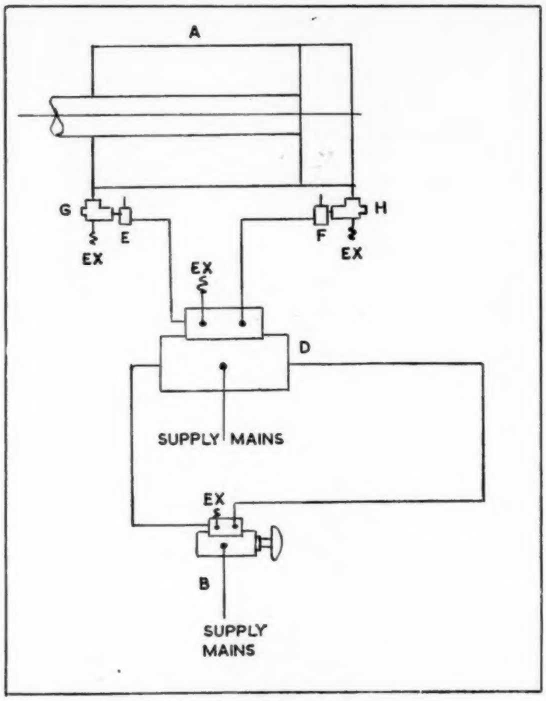


Fig. 9.—Manual operated pilot valve servo system

3. In satisfying the above conditions maximum operating efficiency and air consumption efficiency are obtained.
4. To ease the problem of installation and effect economies in piping, material and labour.
5. To increase the flexibility of application by the wider choice of circuits afforded with the various types of valves available.

Fig. 8 shows the rudimentary principles of a pilot system. Valves B and C are the pilot valves and these are lever and roller action, operated by either linear or rotary cam action. As each in turn is tripped, so will valve D be reversed, thus allowing the main air supply to be linked up with cylinder A via flow valve E on the one side of the piston, and flow valve F on the other side. To give some idea of comparative sizes, A could be an 8 in. dia cylinder, D a $\frac{1}{2}$ in. B.S.P. automatic valve and pilots B and C as small as $\frac{1}{8}$ in. B.S.P. which are light and sensitive, requiring only about 5 to 6 lb effort to operate. To go a stage further, micro-pilot valves would satisfy the conditions of ultra-light action and extreme sensitivity. This type of valve requires but a few ounces effort to operate, with only 0·010 in. movement necessary for its reversal.

In Fig. 9 a similar set-up is illustrated but with the difference that a single pad-operated valve B is used to control automatic valve D (note: pilot valves B and C, Fig. 8, each have a cylinder port blanked off and therefore act only as three way valves). Furthermore, although flow control valves E and F govern piston speeds, because rather high speeds are necessary, quick exhausting valves G and H are used. If valve D is

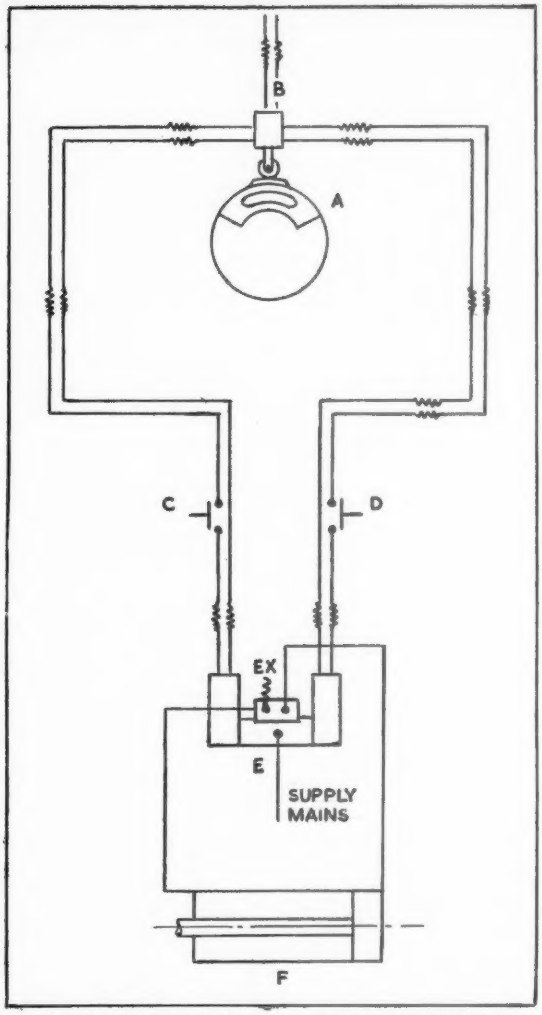


Fig. 10.—Electro-pneumatic synchronizing device for press feed system

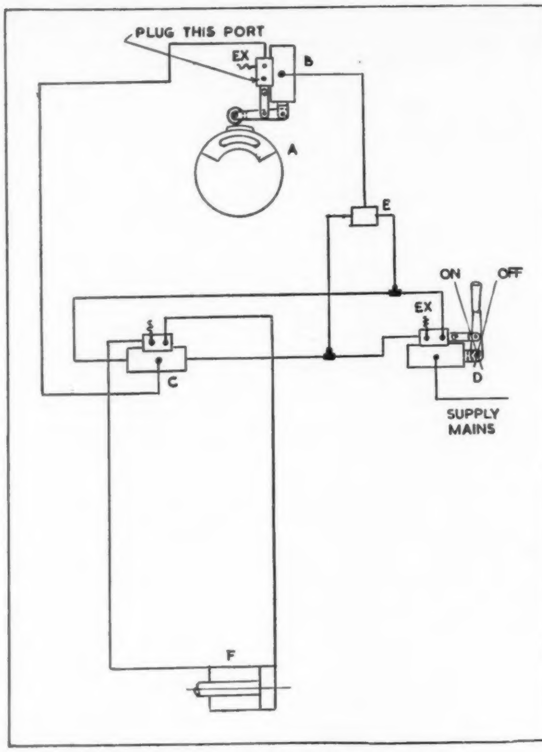


Fig. 11.—Pneumatic synchronizing device for press feed system

placed as near to cylinder A as possible, thus keeping the pipes short, maximum piston speeds should be obtained with this arrangement.

Now for a word in explanation of quick exhausting valves. Such a valve will allow full flow to the cylinder, but when flow takes place in the opposite direction the air is turned to exhaust through a bigger port, so by placing quick exhaust valves almost in the cylinder port, pipe friction of exhaust air is eliminated and this results in a very fast speed of operation. There are various types of quick exhaust valves on the market but the one referred to is very useful inasmuch that it can also be used as a shuttle valve of which mention will be made later.

Synchronization in a pneumatic system

With automatic machinery, where in many cases a pneumatically operated prime mover must be perfectly synchronized with a rotating shaft or moving lever, etc., it is important to establish a reliable circuit for this purpose. There are various ways of doing a job like this and it will already have been noted that on such occasions the electro-magnetic valve is extremely well adapted. Out of general interest a simple example has been chosen which is illustrated by circuits shown in Fig. 10 and 11. Fundamentally the circuits refer to a large power press with roller feed, the latter being engaged and disengaged, quite independently of the press crankshaft, by means of an air cylinder. It is imperative that the roller feed only be engaged or disengaged at a precise point in the rotation of the crankshaft. This can be achieved either by a solenoid valve circuit or a purely pneumatic circuit and hence each system will be described separately.

Fig. 10 provides a simple, straightforward and effective solution. Cam A on the press crankshaft is set and locked in the correct radial position (note: the slot in the cam for phasing adjustment) so that at each revolution it will trip the roller switch B. At the precise point of engagement an electrical supply is made available for solenoid valve E which is a double-solenoid impulse-operated type. This in turn operates cylinder F which is used to engage and disengage the clutch, but the electrical supply is only made available by depressing push buttons C or D to control either engagement or disengagement. At high press speeds, buttons C and D may be depressed at any time since the prime mover F can only operate the feed when A engages B.

Now Fig. 11 differs in many respects although at a glance one can see that four valves are required to take the place of the solenoid valve in Fig. 10 Such recourse, however, may be necessary if for certain reasons it were inadvisable to use electricity. Hand

valve D is a self-exhausting type (self-centring) and by its operation air is supplied to pilot-operated automatic valve C. At the same time air is also supplied to the body of the lever- and roller-operated valve B via shuttle valve E. The idea of a shuttle valve is to supply air to a common point from two different sources but with a complete independance of each source, and for general interest a shuttle valve is shown in Fig. 12. Valve D in either position therefore pilot operates C and provides main supply to B, which has one port plugged up and therefore acts as a three way valve. When cam A trips valve B the air supply from D to B is connected with C as a main supply and hence operates cylinder F connected to the clutch. If hand valve D is operated any time during the crankshaft cycle, but not when cam A engages valve B, pilot air will be supplied to automatic valve C but, of course, no main line air being available from B, cylinder F cannot be operated to engage or disengage the feed. No flow

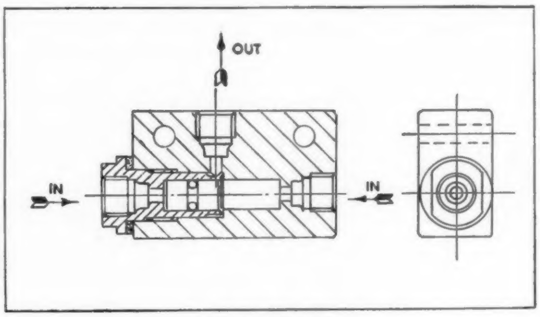


Fig. 12.—Shuttle valve

valve are shown in the above circuits since in practical applications these have not been found necessary. There may be certain cases, however, where there use may be advisable.

Air clutch operation for power press, etc.

Circuits for air clutch operation may be more familiar to the average user than most other applications and the one shown in Fig. 13 is a good example of the combined use of plain pneumatic and electro-pneumatic operation. The usual control requirements are listed hereunder:

1. To run continuously, using positive hand valve D for both starting and stopping.
2. To stop automatically after the completion of one blow. Starting and re-starting controlled by valve D.
3. To inch the crankshaft of the machine and hence the ram by use of valve H (spring loaded to stop position).

Continuous running.—The isolator switch G is thus set and permanently cuts out any electrical connexion between roller switch F and valve E at any part of the stroke. Hence under such conditions valve E plays no part, functionally, in the circuit. Valve D is pulled into the 'start' position when it makes available a supply of air to pilot-operate automatic valve C. In this position valve C will then supply air to valve B via shuttle valve J. Valve B is a pilot-operated (spring to

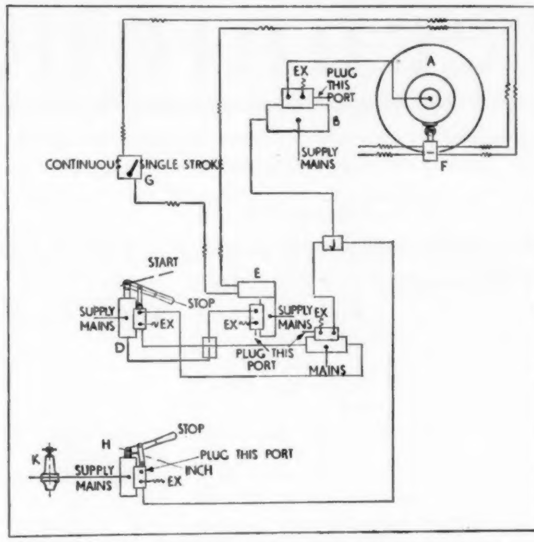


Fig. 13.—Circuit for pneumatic clutch on power press showing single stroke/continuous-stop/start and inching controls

return) master valve which then supplies the clutch and operates the machine. As the machine runs, and cam A repeatedly trips switch F at each revolution, nothing will happen because the circuit is permanently broken. To stop the machine, valve D is pulled into the stop position which by doing so reverses valve C. This cuts off the supply to valve B and exhausts the pilot line via shuttle valve J through valve C, and valve B being of the spring return type, reverses and exhausts the clutch.

Single stroke.—Switch G is set to a single stroke. Valve D is pulled into the 'start' position and the clutch is engaged as previously described. After one revolution of cam A, limit switch F will be depressed thus completing an electrical circuit and energizing the solenoid of valve E. At this point, valve E will be reversed and in so doing supply pilot air to reverse valve D. Should an operator try to retain valve D in the starting position at this stage the handle will be pulled from his grasp. Of course, when valve D is reversed so is valve C and the machine is stopped as described above. To re-start the cycle, valve D is moved into the 'start' position when the pilot air line is then open to exhaust through valve E.

Inching.—Inching of the press may be carried out quite independently of the rest of the circuit by use of spring-loaded hand valve H. This merely supplies air to master valve B, via shuttle valve J, and valves H and B being spring loaded ensure that the return of the hand lever to the 'stop' position on valve H will instantly exhaust the system and disengage the clutch. So that there should be no interference from inching valve H, should this be inadvertently operated, under normal running conditions it is wise to use reduced pressure for the inching system. A differential of a few pounds is enough to sustain shuttle valve J against accidental interference.

Acknowledgment is made to Midland Pneumatic Limited, New Cross, Wolverhampton for information on their unit type valves.

technique

devoted to the discussion of practical problems. Readers are invited to contribute items from their own experience in matters relating to design, manufacture and maintenance. Payment will be made for published contributions.

Any Questions ? **We welcome inquiries concerning difficulties arising out of our readers' general work, for treatment in the technique section. The full name and address of the writer (not necessarily for publication) must accompany each communication**

Modified Carrier-plate for Cutting Multi-start Threads

When cutting two or more start threads with single-point tools in the lathe, troubles and inaccuracies frequently occur. They arise chiefly when having to index the lead-screw or workpiece into the successive starting positions after cutting the first thread. The usual practice is to mark mating teeth in the pick-off gears, then to disengage the gears so that the one on the lead-screw may be indexed to the required new position.

By using the modified carrier-plate of the type shown in Fig. 1 these common troubles and errors can be avoided in a particularly simple manner. The carrier-plate renders it unnecessary to un-mesh the pick-off gears, and also enables the workpiece to be indexed much more quickly.

The flanged carrier-plate A is bored and threaded to screw on to the lathe spindle in the usual way. A number of holes B are drilled and reamed through the flange. All the holes are exactly the same diameter, situated square to the front face of the carrier-plate, and are located on the same pitch circle. The shank of the hardened and ground steel driving-pin C is a close push fit in holes B. The driving-pin is retained by nut D screwed on to the threaded end of the shank which projects at the rear of the flange.

In the example here illustrated, eight holes are provided in the carrier-plate. They enable the carrier to be used for cutting single, two, three, four, and six start threads. It will be observed that holes 1 and 2 are diametrically opposite; holes 1 and 3 are 120° apart; holes 1, 2 and 4 are 90° apart, and holes 1, 3 and 6 are 60° apart. Additional holes can of course be inserted in the carrier-plate when a larger number of thread starts is required.

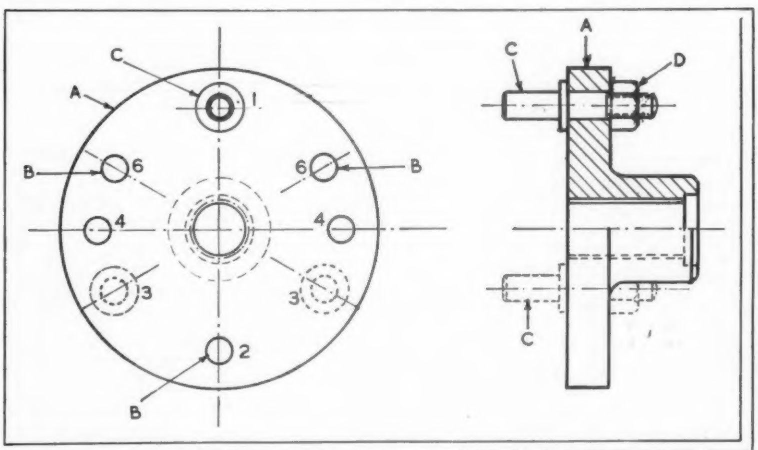


Fig. 1.—Modified type carrier plate

In use, the first thread on the work is cut with pin C inserted in hole number 1. The pin is then removed and placed in the next hole according to the number of thread starts being machined. Throughout these indexing operations the catch of the workpiece remains unaltered.

The catch should preferably be specially made to suit the modified carrier-plate. It should consist of a rectangular bar of case-hardened steel, bored to suit the diameter of the workpiece, and having an accurately spaced reamed hole to fit snugly over the ground projecting end of pin C. By this means slackness and error will be eliminated when indexing the workpiece to the various radial positions.—**H.W.M.**

Predicting Motor Rotation

It is sometimes necessary to ensure that an electric motor, when installed to drive a particular load, will rotate in one certain direction, a

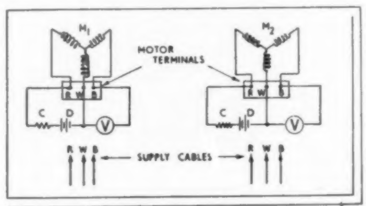


Fig. 1.—Test connexions for predicting direction rotation of motor

trial run being ruled out due to the risk of damage to plant, etc., in the event of the motor starting up in the wrong direction. In the case of a three-phase a.c. induction motor, prediction of direction of rotation when connected to the supply can be effected if an existing motor of known rotation is available.

Referring to Fig. 1, let us assume that the new motor M2 is required to run in the same direction as the existing motor M1, and that the cables which are to supply M2 as well as M1 are marked R, W and B in accordance with standard practice. Disconnect M1, but before doing so, mark its terminals R, W and B to correspond with the supply cables to which they are connected. The motor M1 is then connected to a battery D, a resistance C, and a low reading voltmeter V. The value of the resistance C may be such that the voltmeter reads about half the voltage of the battery. The rotor of M1 is then turned in the direction in which it normally runs, which causes the reading of the voltmeter to increase or decrease, and the direction of the voltmeter movement is noted. After

marking the three leads of the test set to correspond with the markings on the terminals of M1, i.e. R, W and B, the test set is then connected to the terminals of the new motor M2.

The rotor of M2 is now turned in the same direction as M1, and if this causes the voltmeter reading to increase or decrease as in the case of M1, the terminals of M2 are then marked R, W and B to correspond with the markings on the leads of the test set. On the other hand, if the turning of M2 causes the voltmeter needle to move in the opposite direction to that in which it moved in the case of M1, two of the test leads should be changed over at the terminals of M2. The turning of M2 rotor will then cause the voltmeter needle to move in the same direction as it did when connected to M1. When the correct voltmeter movement has been obtained, the terminals of M2 are marked to correspond with the leads of the test set. It can then be predicted that if the terminals R, W and B are connected to the supply lines R, W and B, the motor M2 will then run in the same direction as M1.

Incorrect D.C. Motor Reversal

The writer's attention was drawn to the unsatisfactory performance of a d.c. motor in which heavy sparking occurred at the commutator whenever the motor was operating on load, and the consequent scoring of the commutator surface necessitated constant attention. The trouble had developed after the direction of rotation had been reversed, which suggested that the changeover had not been carried out correctly.

On checking the connexions at the terminal box, the latter component was found to be very inaccessible due to the manner in which the motor had been built into the framework of the machine comprising the load. An enquiry regarding the method adopted to gain access to the terminals elicited the information that the connexions had been altered at the motor brushgear, this presumably suggesting itself as the easier way. Examination of the leads to the brushgear revealed that reversal had been achieved by changing over the leads

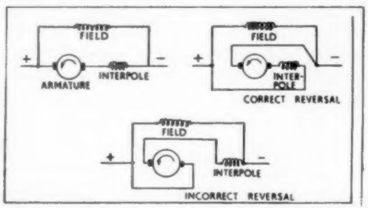


Fig. 2.—Reversal of D.C. motor, illustrating the need for ensuring that interpole and armature connexions remain unchanged on motor reversal

to the brush arms. As illustrated in Fig. 2, this procedure, although changing the direction of the current through the armature in relation to that in the field coils, left the direction of the current in the interpoles unchanged. This was the cause of the trouble, since of course, the relative directions of current in armature and interpole circuits of any d.c. motor must remain unchanged, and to ensure that this condition is not disturbed, the leads from the interpole to the armature should never be broken for reversal purposes.

Checking Lamps in Remote Buildings

A cheap and simple solution to the problem of obtaining a pilot indication of lamps being inadvertently left on in one or both of two buildings situated at a considerable distance from each other and also from the main building containing the source of supply point is illustrated in Fig. 3. A spring-on tumbler switch was connected in the live feed to each building on the supply side of the main fuses, and a pilot lamp of low wattage was joined to the dead sides of these two switches. It will be seen that the condition of switches in the remote buildings can be checked by momentarily opening the spring-on switches. In the event of lamps being left on in building A as shown, then

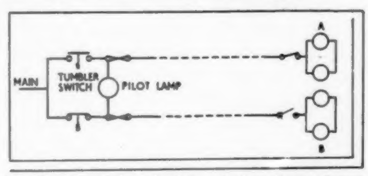


Fig. 3.—Circuit for checking whether distant lamps have been left on

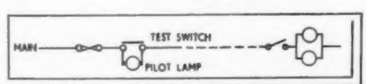


Fig. 4.—Monitoring where only one circuit is involved

opening the A switch will put the pilot and distant lamps in series so that the pilot lamp will indicate. If lamps are left on in both buildings the pilot lamp will show an indication with the opening of both of the spring-on switches in turn. Fig 4 shows an alternative circuit where only one remote building is involved. The same principle can, of course, be applied to other suitable single-phase equipment.

Is Payment by Results Out of Date?

This matter has been featured on TV and reported in the Press. Much fuddy-duddy reasoning has been advanced in support of the contention that the system has had it. From a long experience of incentive production *and* maintenance work, I am in no doubt that payment by results is *not* dated and won't be, in the foreseeable future, while human nature remains what it is. In batch and mass production the nigger in the woodpile is soul-destroying monotony. Consequently, the only real antidote for this fed-upness is the ability to earn big money by means of one's skill and slickness in operating a machine, or by one's manipulative dexterity with tools at bench or vice.

In both cases, making the utmost productive use of every minute of the working day is the sure way of putting that bulge in the pay packet, so ardently desired by the worker and his wife. Payment by results provides the inducement to make the utmost use of time and skill. No other method I've seen or known of, so consistently gets the man to his job on time and keeps him busy there from buzzer to buzzer. Some executives may dislike incentives schemes because they keep them on their toes. The keen, competent pieceworker won't readily work under poor production conditions. Old or defective plant is abhorrent to him; hunting around for tools, material, etc., gets his goat; time is really money to him and when he is forced through poor planning, feeble management or woolly supervision to squander the one, he forgoes the other.

Payment by results, if properly applied, not only ensures that the man at bench or machine delivers the goods on time, it also compels those higher up to get their skates on in the matter of facilities. Everything required by the man in the execution of his task must be within easy reach. Lighting must be good and in the right place, and above all, it must inflict the minimum of eyestrain. Safety precautions must be adequate,

tools must be of highest quality, requiring the minimum of grinding. Slipshod management cannot live with speed-conscious incentive workers. Nor can casual draughtsmen who take the easy way out with tolerances and information generally. Everything the shopman requires of a shop drawing must be on the drawing: 0·0004 in. isn't good enough if 0·004 in. will do the job. Unnecessarily tight limits are money down the drain. Fast incentive workers are the watch-dogs of efficient shop management. If there is sloppy management, and their earnings suffer as a consequence, they become extremely vocal and remain so till the remedy is applied.

I have supervised shops without incentive, shops on the district rate per hour. I have supervised them on a variety of premium bonus systems and on straight piecework—so much cash for the job with no time set—and I am satisfied that straight piecework is the most rewarding for both employer and employed. It has the cardinal virtue of simplicity. When dealing with a cash value instead of a set time, the men know at the end of a shift how much money they have earned. One speaker on TV is reported in the press as saying that the number of workers employed on payment by results has flattened out and even started to fall away. Among other things, he attributes this to "The introduction of new manufacturing methods and to the amendment of incentive schemes to a point where they have ceased to serve their purpose." That, of course, does not mean that payment by results is out of date.

To my mind, it means that the application of the scheme is in ruins, just so much lumber. Over the years, that has been my quarrel with bonus schemes. I always feel that such schemes are conceived to protect bad ratefixing. Early versions limited earnings to time and a quarter, while straight piecework—so much money for the job—in shipbuilding, for example, was based on time and a half. Some bonus systems were so devised that if a time was set too high, after time and a quarter had had been earned, the firm got a proportion of the man's earnings and he got correspondingly less. In effect, the more the man earned, the less he got, proportionately. After two world wars, what with war bonuses and cost of living awards, few of the men could calculate their earnings. In some systems, the amount of bonus was calculated on the man's basic rate, ignoring cost of living or war bonus awards.

How much simpler and fairer to say twenty-five shillings for a given job, irrespective of time taken? That satisfies the men, relieves the foremen and management of a lot of worry, and, if the price is right, gives maximum production. Straight piecework demands expert ratefixing; *any* clerical worker won't do. The ratefixer should have been an operator on the class of work concerned, a *high grade* operator and a fast mover. Given those conditions, straight piecework is a winner for both sides in industry. I cannot see it ever going out of date. Other managerial pronouncements on the subject read: "The many modifications introduced in incentive schemes to make them fair all round had often blunted the effectiveness of the incentive." The modifications, if they were to be "fair all round" should have been framed to give the opposite effect. Again: "Many managements have come to accept the view that to expect the incentive automatically to do some of their work for them is an abdication of management responsibility. The good manager should be able to obtain—from an alert and co-operative work force—additional effort in time of difficulty, even if the operatives do not get extra cash." What nonsense!

To me, the foregoing seems like putting the clock back. Few managers responsible for production will regard it as progress, I fear. Years ago, a novel payment-by-results scheme was introduced on naval torpedo production. It was called the Fellowship System, aimed at making the men largely responsible for shop discipline and production. Briefly, and from memory, straight piecework was employed and the personnel were arranged in squads. The squad earnings were divided equally among the members. If any man was unavoidably held up, he simply turned to and helped another; unproductive time was largely eliminated. Any member not pulling his weight was reported and his removal asked for: the men refused to carry passengers. A few fast men in a squad can work wonders on the slower ones if there is money in it. Speed is infectious, as much so in the workshop as on the road or in the air.—**M. Donald.**

Assembling Special Plastic and Sheet Metal Pointers

The press, whether a hand or power machine, is a fast and efficient tool for some types of assembly methods, and though this generally applies to components produced on that class of machine tool, other details are easily attached to a pressed part if appropriate locations are provided on the press tool.

Fig. 1 illustrates a plastic and sheet metal pointer—the handle being supplied in varying colours to suit special requirements, and the pointers are at this stage offered to the press tool after bright plating has been accomplished. The centre bearing consists of a thin tube about 0·015 in. thick (28 gauge) and this is parted off to length on a capstan to allow for final swaging with the other pieces assembled.

The tube is initially fed to a stop and countersunk slightly to remove any suggestion of burr, and then the tool seen at Fig. 2 is located in the bore and pressure applied to the turret handle. The tool turns over the outer edge of the tube—very little pressure is required because the walls are so thin, but the usual thrust race is essential on equipment of this nature and the two-part

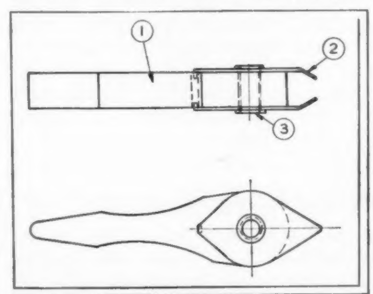


Fig. 1.—The parts assembled ready for use; both the bearing hole and that used for locating the pointer tags are moulded

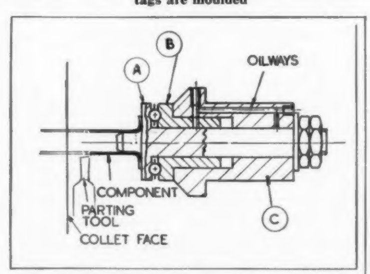


Fig. 2.—The forming of one side of the head is accomplished by the tool shown here, the rotating parts being a special style of thrust bearing

bearing is constructed on these lines. The holder C fits the turret bore and adjustment to ensure a running fit for the race is obtained by the locknuts. An old bearing is often available for either alteration or incorporation, but the inner cage is useful and overcomes the necessity of building another. A firm steady pressure is preferable to a quick jab —once the tube end has been turned to a right angle. Adequate oiling facilities are provided in this tool and the long drilling ensures that the rear portion of the bearing also receives a supply of lubricant.

Plating follows and then the details are ready for the final swaging process in the tool seen at

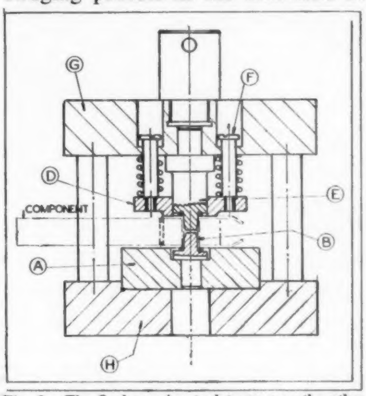


Fig. 3.—The final swaging tool turns over the other end of the tubular bearing and clinches all four parts together

Fig. 3. Both pointers are produced in the orthodox style of blanking and bending tool and one end is turned over to create a small peg which is used to locate in a cored hole in the plastic handle. This hole and peg arrangement ensures that both pointers match each other within a reasonable degree of accuracy, and a clearance between the parts of about 0·005 in. permits easy assembly when the pieces are installed in place without creating a great discrepancy in the pointer tips.

The lower locating plug has a dual purpose to perform—it initially sets the pieces and acts as a die for the final clinching of the pieces together; a careful grinding operation being necessary to obtain the step dimension from the top surface of A to the flange face of this plug B.

All four pieces are assembled by the operator—the bearing and pointers fitting closely as the central hole is moulded to reduce the clearance between the tube. On the downstroke of the press ram the pressure pad D initially contacts the upper pointer and presses it down with the other parts to form a solid assembly. Failure of the pieces to seat at this stage means that a loose set assembly results, and though a second blow might effect a cure, there is the risk the plating will become damaged and so mar the appearance of the handles.

The upper punch E is machined to give the essential curl to the tube and this radius corresponds to that imparted to the rotating portion of the bearing at Fig. 2. Both plugs have generous leads to give an easy entry into the tubular part.

Some careful press setting is required on tools where a decided bump is given to the assembly, and though plastic is not very easily crushed—it at least does not literally fly into splinters—care is necessary to overcome the tendency of forcing the pointers into the surfaces. A wide area means some pressure is required for such a contingency, but the ideal situation is achieved when the tube is turned well over and flattened without severely damaging the plated end. Some experimentation with a few pieces soon gives the desired setting of the press ram and the parts in question were finally held securely and without a trace of shake.

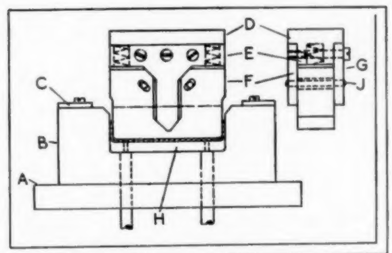
As little or no distortion is caused by this process the assembly is not difficult to remove from the tool, and as the handle is long enough to give a useful and adequate grip, no mechanical form of ejector is incorporated in the design.

Quantities demanded that the four principal parts—the lower member A, the flanged plug B, the pressure pad D and the forming punch E were all case hardened to resist wear and pitting, and to assist in creating a good radius both plugs were polished after the heat treatment process.

Forming Die for Stock of Variable Thickness

The bottom (female) die is of standard design and solid construction being made from a steel block. It is mounted on a die shoe and includes two nesting plates and a spring-actuated holder pad which also serves as an ejector. The punch is of sectional design, with few parts, two of the parts being movable with respect to the other parts. The punch holder carries a driving wedge which is provided with two 45° inclined planes. Two half punches are mounted in a floating manner in the punch holder and are held in position by means of two dowel pins and two guiding plates. In the open position, two strong springs push down the half punches.

In operation, the straight blank is placed in position on the holder pad between the two nesting plates and the punch is lowered, pushing the blank into the die and forming it to the desired U-shape. As soon as the holder pad reaches the bottom position, the punch cannot descend any further, but under the influence of the downward pressure of the press ram, the driving wedge forces the half punches sideways (this lateral movement being possible due to the elongated holes in the half punches for the dowel pins) so that the two legs of the workpiece are pressed firmly against the side walls of the female die. In this manner, any variation in stock thickness is compensated for readily.



Forming die, A, die shoe; B, female die; C, nest; D, punch holder; E, wedge; F, punch; G, guide plate; H, pad; J, pin

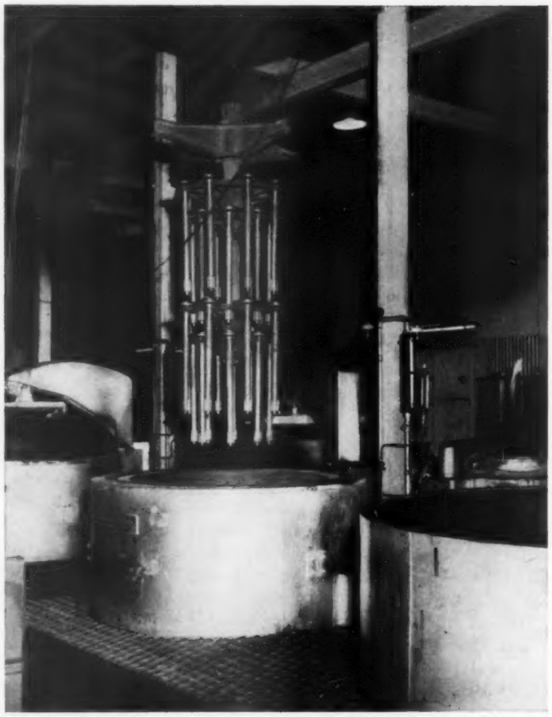
A die of this design can be only used with screw-presses of course (flywheel for manual handling, or friction presses for power actuation) since the stroke, i.e. the bottom position of the press ram, cannot be fixed.—**F. Strasser.**

Silicone Lubricant Prevents Wax Build-up

Wrapping machines which use waxed cartons suffer from "wax build-up"—the collection of wax from the paper on the moving parts. A large ice-cream manufacturer is preventing this by using a silicone spray lubricant; it has been found particularly valuable in preventing build-up on plungers. The lubricant is Ambersil Formula One made by Amber Oils Limited, of 11A Albemarle Street, London W1. It is odourless, tasteless, colourless and non-toxic and is applied from an aerosol pack.

Equipment for Heat Treatment of Axle-shafts

In order to avoid distortion of long and slender parts which have to be heated to high temperatures it is best to hang them vertically, an arrangement for which the pit type furnace is eminently suitable. The axle shafts for the Massey-Ferguson range of tractors are treated in this way by the makers, the Standard Motor Company Limited, in five electrically heated G.W.B. furnaces, each of which holds 32 axle shafts at a time. Each shaft weighs 37½ lb and the full charge is carried in specially designed cast nickel-chromium jigs in two tiers each of 16 shafts. The five furnaces are designed to produce an output of 4,000 hardened shafts per 120-hr week working on a 3¾-hr heating cycle, of which 1½ hr is required for bringing up to temperature, while for the remaining 2¼ hr, the components are soaked at the required temperature. The furnaces themselves are capable of operating up to 1,050°C, although their normal working temperature is 950°C. Each furnace has a maximum electrical rating of 145 kW arranged in one automatically controlled zone, governed by a Foster indicating controller with a 7 in. strip chart giving a continuous visual record of the heating cycle. Delta/star rating reduction is provided, which reduces the input to one-third of the maximum rating after thermal equilibrium has been obtained inside the furnace, and the soaking period then begins. This method of rating reduction is desirable since it reduces undue wear and tear on the electrical contactors. The vestibule opening of the furnaces is 3 ft 2 in. dia while the depth is 6 ft. The loaded jigs hang vertically, suspended from four heavy arms at the top of the spider in slots of heavy cast heat-resisting steel brackets which extend through the insulating bricks to the inside wall of the furnace casing. When the loaded jigs have been lowered into the furnace, the insulated lid is swung over into position, operating a limit switch which permits the heating current to pass to the elements which are of heavy nickel-chromium wire in coil form. These coils are arranged around the inside wall, supported on specially moulded open type fire bricks. In addition to this safety limit switch, a further device, to protect the charge and the furnace, is fitted in the form of an excess temperature cut-out of the fusible type which melts at a predetermined temperature and cuts off the current to the heating elements through a relay in the control panel.



Jig loaded with 32 axle shafts about to be lowered into pit furnace. Corner of quench tank bottom right

During the hardening period, a protective atmosphere is present inside the heating chamber to reduce scaling of the shafts to a minimum. At the end of the cycle, the shafts are lifted up and moved over by means of a hoist running on an overhead mono-rail, and plunged into the adjacent oil-filled quench tank. The oil from all the five quench tanks is circulated through a common cooler, situated outside the heat-treatment shop.

After quenching, the shafts are then moved round to a washing and degreasing machine before being transferred to the tempering furnace line for further treatment.

Constant-pressure Clamping Screw

When gripping large hollow components having thin, weak walls, or those in a particularly soft metal or alloy, inaccuracies, distortion, and cracking frequently occur due to the gripping pressure. The accompanying sketch illustrates a type of clamping screw, for use in jigs and fixtures, designed to avoid this trouble. It applies only a predetermined (safe) clamping pressure.

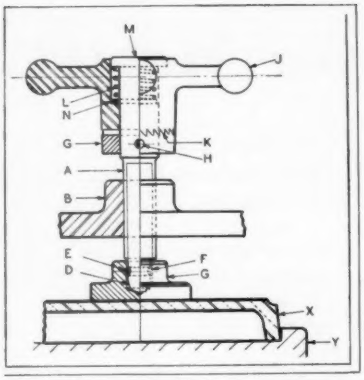
In the particular application shown, the screw is employed in a drill-jig for holding the large hollow casting X made in a soft aluminium alloy. The casting has a very thin unsupported base-wall into which a number of holes have to be jig-drilled. The casting is mounted in jig Y with the open side seating on the face of the jig, and three clamp screws, like the one shown, bear on the thin base-wall that is to be drilled. When using ordinary solid set-screws for clamping, many of the castings were inaccurately drilled owing to distortion of the wall, and numbers were cracked by excessive and unequal gripping pressure.

In the sketch, A is a mild steel screw, threaded right hand for about half its length, and it is screwed easily into the tapped bossed wall B of the jig body. The end of the threaded portion is reduced in diameter for a short distance to form a plain shank which is a slack fit in a blind hole in the circular clamping-pad C. The tip of the plain shank is machined half-spherical as at D, which allows the pad to rock slightly and also rotate so that it can adjust itself easily to the rough surface of the casting X. Pad C is retained by the cross-pin E fitted in the sidewalls of the pad boss, and passing easily

through the half-round annular groove F around the shank.

A narrow hardened steel ring G is fastened by cross-pin H to the plain shank portion of screw A. The small steel handwheel J is bored to be a free-running fit over the same plain shank. The end of the handwheel boss and the adjacent side of the ring G have finely-pitched shallow ratchet teeth K. The teeth are arranged with their straight sides in driving contact when the handwheel is rotated counter-clockwise. This arrangement means that the inclined sides of the teeth transmit the drive to screw A when the handwheel is rotated clockwise for tightening.

A light compression spring L is interposed between the integral head M of the screw shank and the hardened and ground collar N in the bottom of the counter-bored portion of the hole in the handwheel. The collar prevents the spring from being unwound or damaged when the handwheel is revolved during clamping. The coil spring maintains the ratchet teeth in engagement with just sufficient pressure for gripping the workpiece safely. Any further clockwise rotation of the handwheel merely results in the ratchet teeth slipping as the handwheel freewheels on the screw.



Clamping screw for thin hollow components

The pressure necessary for any particular clamping operation is obtained by using a collar N of the required thickness to ensure the necessary pre-compression of spring L. Alternatively, a spring of different strength may be employed.

Storage of Conveyor Belting

The great increase in the amount of plastic conveyor belting being used in mines instead of rubber belting has created a storage problem because of the tendency of rolls of plastic belting to deteriorate if stored in conditions which cause localised pressure. Storing rolls on their sides causes such localised pressure; the alternative of storing them on their ends is wasteful of storage space and handling is difficult.

To overcome these difficulties Mr. T. G. Baker, assistant area general manager of the N.C.B.'s Wakefield area, has designed a storage rack in which rolls of belting are carried horizontally on flexible slings. These slings are made of old conveyor belting, and by giving an even pressure over a considerable surface area of the roll of belting eliminate the local pressure which can cause damage.

The rack designed by Mr. Baker consists of a honeycomb structure of tubular steel. The slings of old belting are carried in cells of hexagonal section, the whole being fabricated from short lengths of tube about two feet long joined by means of standard Kee Klamp 120° two-socket tees.

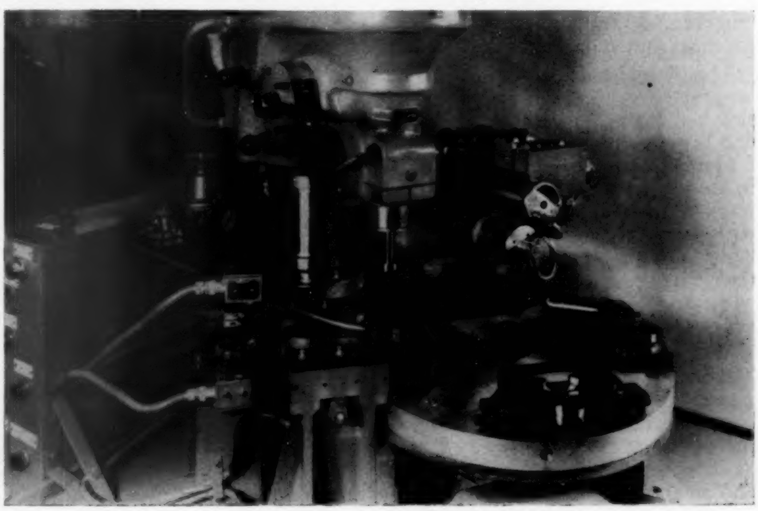
The length of the slings is so arranged that when loaded the bottom of the roll of belting is level with the bottom of the cell, and with a working clearance at the top and side of the cell.

Handling of the belting in store can be conveniently effected by a lift truck fitted with a single pole, instead of the usual forks, operating through the centre of the wooden core now supplied with most rolls of belting.

Fabricating a Floating Pipeline

A pipeline which was recently completed near Limassol in Cyprus, has a total length of 2800 ft, of which 1000 ft is on land and the remainder projects out to sea. At the sea end is a length of flexible pipe attached to a buoy, which tankers pick up in order to unload their cargoes through the pipeline. By this means, diesel fuel can be landed quickly without the need for a jetty. The work was done by the Scientific Welding Company, of Grays, Essex, using Quasi-Arc Radian electrodes. Butt welds received a standard 60° V preparation and the first run was carried out with 10 swg. This was followed by two runs of 8 swg. The whole pipe was then covered with Bitumastic for protection.

The pipe was first of all fabricated into lengths of 600 ft and these lengths were launched by being placed on a series of bogies which ran out to sea on Jubilee track. The track curved round in a semicircle and then returned to the shore. When the pipe reached deep water, it floated up from the bogies due to the buoyancy of the oil drums attached to it at regular intervals. The bogies automatically returned to the shore around the semicircular track. As one section was launched, the next section was lined up and welded to it until the job was completed. Despite the length and weight of the pipe, the whole launching operation took only 13 hr.



AUTOMATIC MACHINERY.—This special piece of equipment is for chamfering a circular collar, the indexing table permitting work to be loaded while machining is in progress. The jaws of the V-blocks are operated by a pneumatic cylinder. The chamfering operation is entirely automatic and an operator has only to load the components into the open V-block after which the table indexes, is locked, machining spindle advances and retracts automatically. At the next station the components are automatically ejected. Air blast is used for the removal of swarf and cooling by air-oil mist is employed at the machining station. The cycle of the machine is controlled electrically by microswitches and solenoid operated valves, and the chamfering spindle is actuated by a Pacera Maxam air hydraulic feed unit which provides automatic operation. The equipment was supplied by W. J. Meddings Limited to a German car manufacturer

Light Alloys for Mobile Structures

Saving in weight increases payload and the use of corrosion resisting alloys reduces maintenance and lengthens useful life, particularly in equipment in constant outdoor use

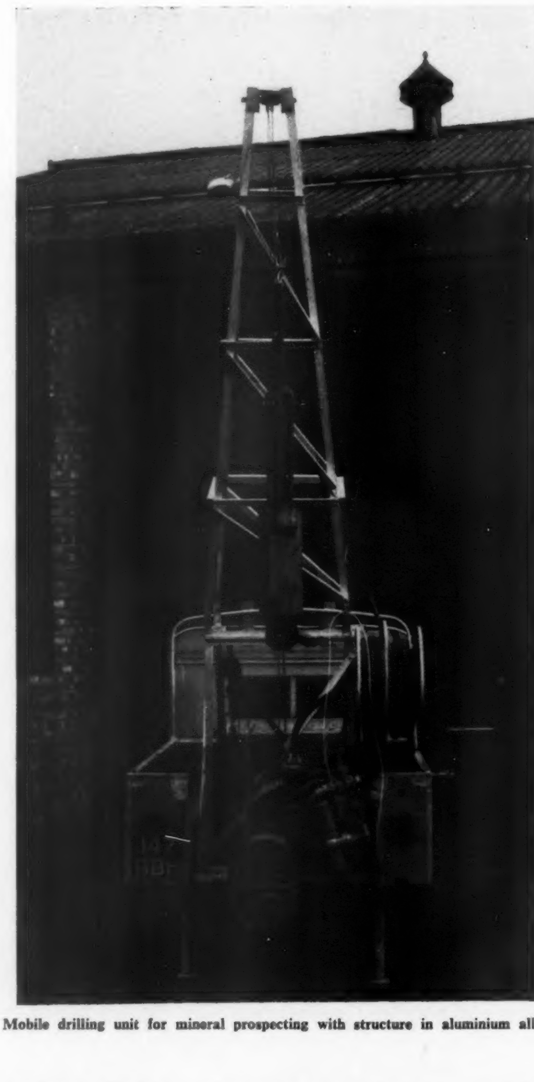
THE natural desirability of a structure is that it has to support its own weight. This is of little consequence in small structures but it is critical with great height or long span. With any size of structure, however, weight in the wrong place is undesirable, and this is particularly the case with top hamper, as in ships' superstructures which are now being made in light alloy, and in tall vehicles. With vehicles, too, the unladen weight is important (as it is with ships) and a saving in weight without diminution of strength is always a decided advantage. Another advantage of light alloys in vehicles is their natural resistance to corrosion which greatly reduces maintenance cost and lengthens the useful life. The practical realisation of these features is illustrated in the following notes on two rather different examples of vehicular structures.

A folding aluminium alloy derrick is one of the features of a mechanical jet drill mounted on a Land-Rover, which has been designed and manufactured in this country for use in mineral prospecting by French geologists in West Africa. The rig is used to position a mechanical hammer that drives tubing into the ground in order to obtain sub-surface samples, which are forced up and out of the tube under pressure from a water-jet. Normally hand-operated drills of a type which breaks down into 60 lb head-loads for transportation and which requires a crew of 10 or 11 men are used on such expeditions; so where native labour is very cheap and plentiful they are ideal, but with the rising living standards of many natives they are becoming uneconomic. This new unit, which requires only a crew of five, is equivalent to four hand-drills, and is expected to bore between 180 and 240 ft per day in areas where drilling depths are unlikely to be greater than 30 ft; designed by Dr. J. R. F. Joyce and built by Davenport Vernon Limited, it offers a quicker and cheaper method of drilling that is suitable for most minerals.

The drive-head consists of a cast-steel block—the hammer—weighing 250 lb, which forms a loose-fitting sleeve about a $2\frac{3}{8}$ in. dia tube which is fitted with upper and lower stops to contain the block. The lower stop is a $5\frac{1}{2}$ in. dia pallet to which the drive-pipe is screwed prior to the commencement of drilling. The hammer is attached by cable to an automatic winch, which is connected to a rear power take-off drive through an electrically operated clutch. The cable operates through a system of pulleys that provides the necessary back tension to enable the winch to pick up the hammer and the latter to operate at various heights.

When the hammer falls—through a distance of 2 ft 6 in.—it strikes the pallet at the lower end of the drive-head and causes a travel switch, attached to the top stop to close; this completes an electrical circuit and so energises the clutch operating the winch, which then raises the hammer until it touches the switch, breaking the circuit, and making the hammer fall again. The rate of operation is designed to be 60 blows per minute, but by varying the engine speed a range from 40-80 blows per minute may be covered.

In order to carry the derrick, drive mechanism, winch and pumping equipment, and also a 60-gal water tank, the vehicle was specifically modified to increase its payload by welding stiffeners on the underside of the chassis and fitting supplementary rubber springs to those at the rear. With a load over the normal maximum, weight saving wherever possible was of prime importance and so the use of aluminium alloy for the derrick was considered



Mobile drilling unit for mineral prospecting with structure in aluminium alloy

The use of aluminium alloy in the construction of this concrete mixer has enabled a payload of seven cubic yards to be obtained compared with one of six cubic yards with a steel drum on the same chassis

essential; using Noral B51SWP—an alloy with a high strength/weight ratio, supplied by Northern Aluminium Company Limited, who also assisted with the design of the structure—the weight was only 80 lb. This showed a saving of 60 lb compared with an equivalent tubular steel derrick, and kept the total load on the chassis just below the maximum allowable. An additional advantage gained by using aluminium is that the structure is used unpainted as the natural oxide coating on the metal protects it from all weathers and renders painting unnecessary.

The derrick, which is 14 ft high when extended, is constructed of $1\frac{1}{2}$ in. × $\frac{3}{16}$ in. angle. Reinforced at certain points with 6 swg sheet, also of Noral B51SWP, it is fastened with anodised alloy bolts secured with self-locking nuts. It is bolted to the chassis through a base-plate at six points where the tops of the chassis members have been specially built up to ensure that the structure is firmly anchored. While the vehicle is travelling the upper portion of the derrick is folded over the cab and secured by an elastic rope to the spare-wheel mounting on the bonnet.

An auxiliary trailer tank of tank-chassis construction with a capacity of 250 gal, provides ample water for 2-3 days' drilling, provided the correct water-recovery procedure is followed; it also carries 200 ft of drive pipe.

A mobile concrete mixer, made of aluminium alloy to give reduced weight and increased payload, which is the first of this construction to be used in Great Britain, and probably the first anywhere, has recently been overhauled after its initial two years in service, in which time it carried over 14,000 cu yd of concrete. During this overhaul, undertaken by Frederick Braby & Co. Limited of Bristol, the fabricators of the aluminium work, it was found that the alloy shell was in remarkably good condition and that the interior had been reduced in thickness due to abrasion by the concrete aggregate by only 0·020-0·030 in. The steel mixing blade, by comparison, had been considerably worn, by approximately $\frac{1}{16}$ in. all over and in places to a knife-edge.

This aluminium alloy mixer, which is no different in basic design from a steel one, was built in September 1955 and put into regular service by F. Bowles & Sons Limited of Cardiff early the following year. The drum is approximately 7 ft dia and 12 ft long, and weighs 1,500 lb; it was made throughout from $\frac{5}{16}$ in. thick Noral B54SM plate with stiffening rings in Noral 54SM bar. The plate was argon-arc butt welded both inside and outside and the heavier rings were Argonaut welded on the outside. The interior spiral blade was made from $\frac{3}{16}$ in. steel plate bolted to Noral aluminium alloy brackets welded to the inside of the drum.

The use of aluminium alloy for the mixing drum, and also for the auxiliary items such as the sub-frame, water tank, and concrete chute, enabled the payload to be increased from 6 cu yd to 7 cu yd compared with a steel drum on the same chassis. This has meant that the number of journeys necessary has decreased, with savings in time, labour, fuel and maintenance. Additional savings have been effected by the reduced fuel consumption and wear and tear on the return journeys of the empty mixer.

Since the introduction of this mixer in 1955, two others of the same capacity have been put into service by F. Bowles. These three 7 cu yd mixers are enabling this company to obtain increased payloads, but even where such large capacities are not required, the use of aluminium to reduce the weight of smaller mixers will not only show substantial savings in operating costs but may also enable a smaller, lower-priced chassis to be used in the building of a vehicle to carry the same payload as a mixer embodying steel equipment.

Flame-plating Tungsten Carbide Increases Gauge Life

A method of literally 'blasting' tungsten carbide on to a workpiece, the Flame-Plating process has been used with success in America for some years, and has been applied to many kinds of precision products where increased wear resistance is of paramount importance. It is claimed that plug gauges which have been processed have outlasted solid sintered tugsten carbide by as much as three times and hard chrome-plated gauges by twenty times; also, being less fragile, they are less subject to edge-chipping and breakage.

The Flame-Plating process patented by the Linde Company of U.S.A. involves the use of a specially-constructed gun in which particles of tungsten carbide are suspended in a mixture of oxygen and acetylene. When this mixture is ignited, a detonation takes place which heats the particles to a plastic state and hurls them from the barrel at supersonic velocity where they embed themselves in the surface of the workpiece. A microscopic welding action takes place, resulting in a tenacious bond. By means of successive detonations, the coating on the workpiece may be built up to any desired thickness over a range from 0·002 to 0·010 in., and may if required be finished by standard diamond finishing methods to fine tolerances. A special advantage of the process is that although the temperature of the gases inside the gun may reach as high as 6000° F, the temperature of the workpiece rarely exceeds 400° F. There is therefore little chance that the part being plated will warp, or that its metallurgical properties will be changed.

At present, tungsten carbide is the only coating being used by John Harris Tools Limited, Millers Road, Warwick, the sole licencees in the United Kingdom for the Flame-Plating process, but aluminium oxide is shortly to be introduced.

Mammoth Coal-getting Machine wins Five ton per min

The National Coal Board has purchased what is claimed to be the world's most efficient coal-getting machine—the £50,000 Goodman continuous miner which will win considerably more coal per shift than is being obtained from any coal mining machine at present operating in Europe.

The machine, which has been developed to a high degree of efficiency in the United States from a British coal-getting machine, has been assembled in Cumberland by Distington Engineering Company Limited, a subsidiary of The United Steel Companies Limited, Sheffield, who are the sole licensees for the United Kingdom.

Two large four-armed rotors and an outer cutting chain comprise the cutting mechanism, both rotors and chain being equipped with a number of extra-hard cutting picks. The machine bores into the coal face at the rate of 10 to 15 in. per min over an area of 7 ft 6 in. high by 13 ft 6 in. wide. Simultaneously, the cut coal is automatically fed back through the centre of the machine to a discharge conveyor.

Cutting principle

The principle of full face mining was developed from the simple idea of using a number of picks on a pair of rotating arms, with a trimming chain to cut the profile. In American machines, this profile can be adjusted to local requirements, but for this machine it has been modified to cut only a fixed and predetermined profile, thus facilitating roof support in conformity with British support rules and regulations. Two large cutting arms rotating in opposite directions together with the trimming chain make up the cutting head, all being fitted with extra hard cutting picks.

The body of the 32-ton miner is mounted on caterpillar tracks, which exert the force necessary to keep the cutting head into the face. A high-speed chain conveyor gathers the coal in front and carries it through the machine, the discharge height being varied according to the conveyance behind. Each track is capable of separate operation, thus giving a high degree of manoeuvrability, and because "grousers" are fitted to the tracks, the machine has worked successfully on gradients up to 1 in 4, either to the rise or to the dip. The low centre of gravity reduces any tendency to dig or climb to a minimum. All movements of the machine, except cutting, which is electrically powered, are effected by hydraulic motors.

Cutting speed and pattern

Cutting speed depends upon the nature of the coal and can vary between 10 and 15 in. per min. The profile shown in Fig. 1 gives an output of from three to five ton per min. Output per shift depends upon the facilities available to deal with this load, but machines are running in America at outputs of over 1000 ton per shift in some cases. Conventional transportation methods are not adequate, and new and revolutionary methods are being evolved. It is hoped to employ one of the latest and most successful, the Goodman Ropex belt conveyor, at Pentreclwydau colliery, Area 9 in the Board's South-West Division where the new machine will shortly go into service.

Most of the unprepared coal face is cut and broken by the two rotating units, each equipped with a double core barrel, two short arms, and two long hinged arms which lock in the extended positions. Tungsten carbide tipped cutting picks, mounted on the arms, cut two or three concentric kerfs in the face, a further two kerfs being cut by picks on the core barrel. The shorter arms of the rotor are wedge-shaped, so that the cores between the kerfs are broken out as the machine advances, while each of the longer arms is equipped with a deflector plate. In conjunction with the forward movement of the machine, this has the effect of directing the cut coal towards the centre of the miner, forcing it on to the central conveyor, whence it is carried back for discharge on to the main conveyors The discharge conveyor can be swung 40° from centre in either direction, and elevated up to 3 ft from a minimum discharge height of 3 ft above the floor.

To complete the periphery of the cutting pattern, there is a cutting chain, also carrying picks, which forms a kerf joining the concentric kerfs cut by the rotor. Cut-out sprockets on the corners of the chain provide a profile which is straight and wide across both top and bottom, making it easier both to manœuvre the machine and to set roof supports in its track. Finally, wedge-

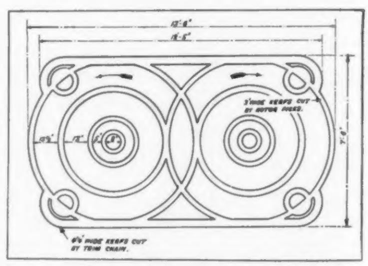


Fig. 1.—Profile of cutting arms and trim chain with special corner sprockets

Goodman continuous miner, showing the discharge conveyor, which can be swung 40° from centre in either direction, and elevated up to 3 ft from a minimum discharge height of 3 ft above floor level

The rotating units which cut into the coal face, removing between three and five ton of coal every minute

shaped cutter bars at the top and bottom of the chain break off that section of the face which is not reached either by the rotating arms or the cutting chain. As a result of this method of cutting, the machine produces a good proportion of lump coal, comparing favourably with lump coal obtained by conventional methods.

Cutting head movement

The complete cutting assembly and the 150 hp driving motor are supported on four hydraulic jacks which can be adjusted to enable the machine to follow irregularities in the seam. Two of these jacks permit a lateral movement of the head of 5° on either side, while the other two make it possible to tilt the cutting assembly up to 4° forwards or backwards from the vertical.

Each of the caterpillar tracks can be reversed or driven forward independently of the other, and the machine can be turned within a radius of 15 to 20 ft on the inside of the turn, without backing up. For tramming, it is possible to retract the top and bottom cutting chain sprockets and cutter bars, and to fold the long hinged arms of the rotors inwards. In this way, the overall width of the machine including the rotors is reduced from 13 ft 6 in. to 10 ft 2 in., and the overall height from 7 ft 6 in. to 6 ft 1 in.

Electrical equipment consists of a 150 hp a.c. motor for driving the cutting assembly and a 37·5 hp a.c. motor for the hydraulic system, which together with the necessary controls were manufactured by Laurence Scott and Electromotors Limited, Norwich and installed by Distington.

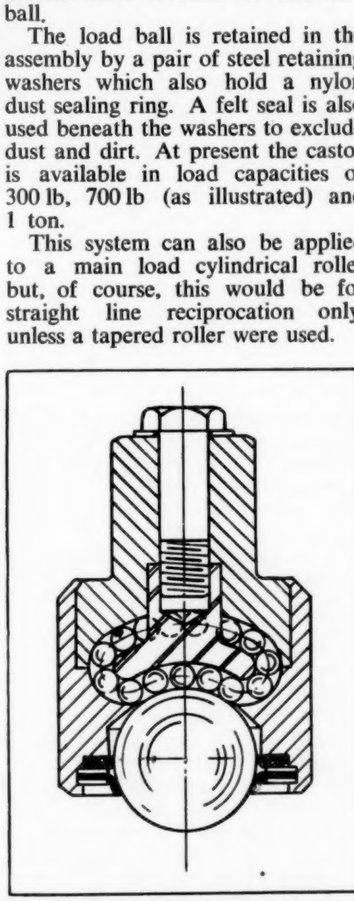
The 37·5 hp motor drives three hydraulic pumps—one actuating hydraulic traction motors for the tractor drives, one supplying power for the conveyor drive and the third supplying power for fifteen hydraulic cylinders. Eight of these cylinders operate the retraction mechanism, the remainder operating the head tilting and elevation, and discharge conveyor swing and elevation. For high speed tramming, the hydraulic pump serving the conveyor drive can be used to supplement the output of the pump supplying the tractor drives.

Ball Bearing Supported Ball Castor

A single ball supported by a bed of smaller balls which are free to circulate in an endless pattern is the principle of the Universal ball castor developed by Autoset (Production) Limited, Stour Street, Birmingham 18. From a study of the illustration and the sectional drawing it will be seen that the motion contact against the 1 in. load ball causes it to rotate on a bed of $\frac{5}{32}$ in. balls above it, which recirculate over the lip of a concavo-convex table, underneath the convex surface and feed in over the opposite lip, thus providing an endless track of balls for the load ball.

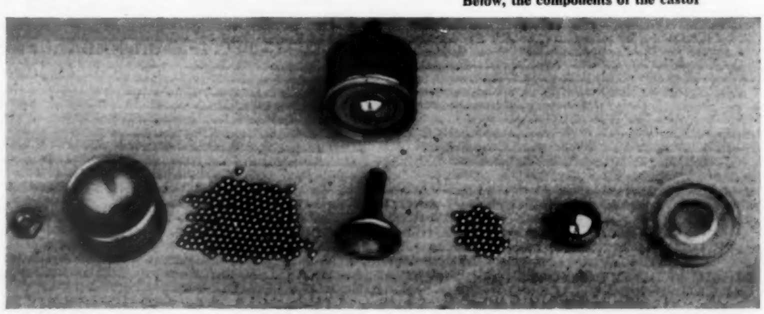
The load ball is retained in the assembly by a pair of steel retaining washers which also hold a nylon dust sealing ring. A felt seal is also used beneath the washers to exclude dust and dirt. At present the castor is available in load capacities of 300 lb, 700 lb (as illustrated) and 1 ton.

This system can also be applied to a main load cylindrical roller but, of course, this would be for straight line reciprocation only, unless a tapered roller were used.



Above, section showing the construction of a 700 lb capacity Universal ball castor

Below, the components of the castor



Sceptre—3

The Aldermaston thermo-nuclear apparatus Sceptre-3 is a companion development to Zeta, being a torus in which a gas is constricted by the pinch effect and in which very high temperatures are produced as a result of heavy induced currents. The developments at Aldermaston were described by Dr. S. Kaufman, of the A.E.I. Research Laboratory, in an address given earlier this year at the Instruments, Electronics and Automation Exhibition. Some extracts from the address, including references to the physical measurements made on hot ionized gas, are given below

WITH the disclosure that controlled thermo-nuclear reactions have probably been observed in the laboratory the way now seems open to producing power from the fusion of the light elements. To produce power from nuclear reactions a reaction must be selected in which energy is released. In particular nuclear reactions involving the two isotopes of hydrogen—deuterium and tritium—are especially favourable. These reactions are sometimes known as fusion reactions because the nuclei are fused together to form more-complex elements. For example, one of the two ways in which neuterium nuclei, or deutrons, can be fused together is:

$$D + D \rightarrow He + n + \text{energy}$$

—a deuteron fused with another deuteron to give a helium nucleus, a neutron, and energy. This energy released is very great: in fact for a nuclear reaction of this type this energy is about a million times greater than that released for the combusion reaction of carbon and oxygen.

The main difficulty in getting a fusion reaction to work is the high temperature required—hence the name thermo-nuclear reactions. These reactions are only detectable by the most sensitive means if the temperature is about a million degrees, and here is necessarily excluded experiments involving the acceleration of particles as in atom-smashing machines because no temperature could be properly defined. Still higher temperatures are required before useful energy will be available. About 1650°C is the hottest region of the bunsen burner. A little higher is the sun's surface, with a temperature of about 6000°C, Zeta and Sceptre, to date between 3 and 5 million °C, the sun's interior, about 15 million °C and, finally, the break-even of critical temperature of a deuterium fusion reactor, 300 million °C.

In a thermo-nuclear reactor, first the hot gas must be confined to a central region of the containing vessel, away from its walls. Second, confinement can be achieved by using a magnetic field as an invisible wall. At fusion temperatures the deuterium is virtually completely ionized and is termed a plasma. In a plasma the concentrations of electrons and positive ions is very nearly equal. The electrons spiral about the magnetic lines of force and are easily anchored to them. The positive ions must follow suit to preserve the approximate neutrality of the plasma.

A magnetic field suitably designed can be made to act as a magnetic bottle and to keep the hot plasma away from the walls. The vessel containing the gas can be made in the form of a torus closed upon itself so that there is no problem of losing heat at the ends. There is, however, one way in which heat is definitely lost, i.e. by electro-magnetic radiation such as light or X-rays. In a thermo-nuclear reactor of practical size there is no way of trapping this radiation within the plasma but fortunately the radiation, although large, is not prohibitively so. On the assumption that radiation is the sole heat loss it is estimated that a critical temperature of about 300 million °C or Kelvin in a deuterium plasma would be necessary before useful power is available.

Some form of constraining magnetic field is necessary to contain the plasma and probably the simplest magnetic configuration is that associated with the pinch effect. A plasma is a gaseous electrical conductor and can be linked to an ion conducting current.

Linked with the conductor are circles of magnetic force which are concentric with the axis of the plasma or conductor, and with the influence of this magnetic field each electron moving along the length of the plasma will be acted upon by an inward force towards the axis. If the current carried by the plasma is sufficiently large—for example, in some cases greater than about 1,000 amperes—this force will be adequate to pull the electrons, and hence the plasma as a whole, away from the walls towards the tube axis. A similar effect is observed when two parallel wires placed side by side conduct current in the same direction.

Unfortunately, when a plasma is confined in this way, using its self-magnetic field, the system is unstable. The earlier experimental work based on the pinch effect was always marred by at least one of several instabilities: for example, the plasma would remain stable for a very short time and then wriggle about in the tube until eventually it struck the walls and was rapidly cooled.

Later theoretical developments have shown that the plasma can be stabilized by the creation of a longitudinal magnetic field in a metal torus before the hot plasma is formed within it. The magnetic lines of force of this field, like those in a solenoid, run parallel to the axis along the length of the torus. If the pinch is formed with the plasma sufficiently hot most of the lines of force are dragged with the plasma and they are "trapped". Under certain conditions the trapped magnetic field stiffens the plasma and prevents it from performing small wriggling movements. Large wriggles are eliminated by the action of eddy currents induced in the metal walls of the torus.

During the first half of 1957 two small pieces of apparatus were constructed in the laboratory at Aldermaston. They were based on stabilizing a constricted discharge by the means described above. The two assemblies had been given the pet name "Sceptre". When the success achieved with Zeta at Harwell was disclosed to the group at Aldermaston it was decided to modify

an existing large torus and not to wait for the smaller versions of Sceptre to be completed. This larger assembly, Sceptre 3, began to produce high temperatures towards the end of November 1957. At the same time a smaller assembly in the United States, known as the "perhapsatron" was being built. It first produced neutrons on December 17, 1957.

The torus of Sceptre 3 is composed of eight sections of aluminium which are electrically insulated from one another with porcelain rings. The vacuum seals are made of indium wire. The tube bore is 12 in. or about 30 cm, in contrast to 39 in. or 1 metre in the case of Zeta. The torus is well evacuated before discharges are produced. With a 6 in. mercury vapour pump the best vacuum so far achieved has been 7×10^{-7} mm of mercury. Deuterium is allowed to flow into the torus through a needle valve until a pressure of 10^{-3} mm of mercury is attained. Both ionization gauges and Prani gauges to record gas pressure are disposed at convenient positions round the torus. Energy is fed into the gas and the hot plasma is formed by inducing large electrical currents in the gas. The gas acts as a single-turn secondary of a large transformer. An iron core links the torus with a primary winding of 8, 16 or 32 turns. A condenser bank with a capacitance of 150 microfarads can be charged to voltages up to 30 kV. The spark-gas switch of the primary circuit is closed to discharge the condenser bank.

Physical measurements performed on Sceptre 3 are characterized by their diversity and by the transient nature of the stabilized discharge. They include electrical measurements, by means of which are measured current, voltage and inductance; high-speed photography, by means of which it is possible to study the stability of the discharge; spectroscopy, by means of which gas temperatures are measured and gas purity studied; neutrons with the eventual aim of showing conclusively that they are of thermo-nuclear origin; and, finally, X-rays, which are produced in Sceptre 3 and also in Zeta.

A feature of these measurements is that the discharge only lasts for about one millisecond, and though from the point of view of the electronic circuitry this is not a short time, when examination of the light emanating from the discharge is attempted, as in spectroscopy or high-speed photography, instrumentation is very often strained to the limit.

Another general difficulty is that the measurements might disturb the condition of the plasma, as for example if a measuring probe consisting of a wire or a magnetic loop is introduced. On the other hand, it has been found possible to display simultaneously most of the measured parameters temporarily resolved on a 12-channel oscilloscope, which instrument has simplified the work enormously. For instance, one oscillogram trace shows voltage measured around the torus, the abscissa being time, others show the current and the time derivative of the current dI/dt. The current and dI/dt are measured with two identical coiled coils, one for each type of measurement. The coiled coil consists of a coiled loop of wire with approximately 10 coils per centimetre of its length. The loop is placed around the bore of the torus. The current is oscillatory and the circuit inductive. Peak currents in the range 20,000 amperes to 200,000 amperes conducted in the gas have been measured. At about 50 microseconds after the initiation of the discharge there is a sudden change in the slope of the trace for dI/dt. This corresponds to a change in the inductance of the gas when the discharge has left the walls. If the longitudinal magnetic field used to stabilize the plasma is of the correct magnitude—e.g. 400 to 600 oersteds—a stabilized pinch is formed. Thus far it has been possible to contain the plasma for about 400 microseconds. The reverse process occurs when the current is decreasing. A stage is reached when the inward pinch force is too weak to contain the plasma; the compressed lines of force within the plasma expand and the plasma is forced to the walls.

These results on the formation of the pinch are qualitatively complemented by high-speed photographic records using a rotating mirror camera. The "object" is a window of the torus. The revolution of the rotating mirror causes the image of the window on the photographic film or plate to be swept across it. The simultaneous recording of two streak photographs is produced by viewing through two windows mutually at right angles. In this way the actual spatial distribution of the plasma can be determined. The internal walls of the torus are indicated by lines. The discharge starts in time at the left. The hot plasma, indicated by a bluish-white light from ionized impurity atoms, is well isolated from the walls of the tube, and takes up a very strong central position.

The principle of temperature measurement is the Doppler effect in light waves which manifests itself in a change of wavelength or colour of the light emitted by atoms moving in the line of sight of a relatively stationary observer. If the source of light is a plasma at a high temperature, the distribution of speed amongst the atoms is Maxwellian and a spectral line focussed on the photographic plate of a spectrograph is not sharp but broad and diffuse, because of the Doppler effect associated with the continuous range of speeds encountered.

The Doppler method of measurement cannot be applied directly to a pure deuterium plasma at a temperature of about a million degrees, for then the gas is for all practical purposes fully ionized and the deuteron emitted no line spectrum. Nevertheless, fortunately from this point of view the plasma of Sceptre 3 is somewhat contaminated with oxygen. Under existing conditions, most of the oxygen atoms within the central core of the pinch lose only four and not all of their eight electrons. These quadruply ionized oxygen atoms are still able to emit a line spectrum. Doppler broadening of the lines of that spectrum can be studied and the shape of the broadened lines can also ideally be used to indicate whether a true temperature is being measured, namely whether the distribution of atoms speeds are Maxwellian.

In the optical arrangement used for measuring ion temperatures, light from the torus is collected by a collimating lens and focussed on the slip of a spectrograph. The spectral lines recorded on the photographic plate of the spectrograph are scanned with a microphotometer. The highest temperature measured thus far was 3·4 million degrees Kelvin, and the accuracy corresponds to a standard error of about $\pm 20\%$.

Most of the measurements on ion temperatures have so far been carried out without temporal resolution. A series of measurements are being made with some degree of temporal resolution but much work has already been done on the excitation of spectral lines, both temporally and spatially within the torus. For that, use has been made of an ultra-violet monochromator to the exit slit of which has been fitted a photomultiplier with a quartz window.

From the degree of ionization of impurity atoms, it is hoped to obtain some idea of the value of the electron

temperature as distinct from the ion temperature. In addition, it can be inferred that spectroscopy is a very useful tool in indicating the purity of the plasma.

Once it was certain that high temperatures had been obtained in Sceptre, a search was made for neutrons using a liquid scintillation counter. The principle of operation of the counter is as follows. Suppose a neutron enters the head of the counter. There is a strong probability of the neutron colliding with a proton of the liquid phosphor. Photons of light emitted by the motion of the recoil protons in the phosphor are collected by the photomultiplier. The signal after suitable amplification is detected by scalers. The scintillation counter not only detects neutrons but other forms of radiation, such as X-rays. A thick lead shield with which to surround the counter had been ordered and on the day when the counter with its shield was ready for use eyes were anxiously glued on the scaler attached to the scintillation counter. Radiation was still detected. The count ran: 7 (i.e. 7 neutrons), 7, 2, 11, 3, 12 and so on. It was an encouraging start, for the background count was very much lower. On changing the gas from deuterium to hydrogen the radiation count fell to a low level. This was even more encouraging, for at a temperature of several million degrees no neutrons should be detected from a hydrogen plasma. After conducting several more crucial experiments, including an activation test with indium foil, it was clearly demonstrated that neutrons had been detected.

Many measurements have already been performed in studying the variation in neutron yield with some of the discharge parameters. The maximum neutron yield occurred at approximately the theoretically predicted magnetic field for stability. This, together with other pieces of evidence—as for example, that the neutron yield was consistent with a temperature of a few million degrees—lent strong support to the case that the neutrons had arisen from true thermonuclear reactions. However, conclusive proof will in all probability only come when there are sufficient neutrons to study their distribution and energy.

Control of Concrete at Berkeley

The concrete structure of a nuclear power station is designed on the basis of definite physical and biological requirements and close control over the materials and methods used is therefore necessary. How this control is effected at the Berkeley station, now under construction, is described

OVER $\frac{1}{2}$ million tons of concrete will have been placed by A.E.I.–John Thompsons' sub-contractors, Balfour Beatty & Co. Limited, and John Laing & Son Limited, when the second reactor at Berkeley Nuclear Power Station goes critical in 1961. Strict control of materials and concrete is being maintained by a site laboratory equipped by John Laing and staffed by A.E.I.–J.T. engineers in association with engineers from the two civil contractors. Apart from specialized use, as in the biological shields, large tonnages are used for the reactor, boiler and blower foundations, cooling water pump house, cooling ponds, offshore works, turbine hall, grouting for precast tunnel linings, and ancillary buildings.

Tests are conducted on all incoming materials—aggregate, sand and cement to ensure that they conform with BS 882, 812 and 12 respectively. Tests for aggregate include sieve analyses, silt and organic contents, specific gravity and absorption determinations together with determinations of aggregate crushing values.

Aggregates are supplied by six quarries—Wickwar, Cromhall, Alveston, Chipping Sodbury and Tythrington whilst sand is received from Grimley (Worcs.) and Bickford. Cement is supplied by the Cement Marketing Company and the Tunnel Portland Cement Company. The bulk used is normal Portland cement although a little rapid hardening cement is used. All deliveries are tested for soundness, compressive strength and setting time.

Tests of concrete workability for compaction are made at the laboratory with a standard Concrete Tool Supply Company rig, whilst a mechanical rig is used on site. After determinations of the compacting factor have been made and the limits of 0·86–0·94 checked, cubes are cast over and tested at 7 days and 28 days to arrive at the density. A Dennison compression machine is used for strength determinations.

For general use a compressive strength of 3000 psi at 28 days is required, although in some instances—as for water retaining structures at the cooling pond—4500 psi is required. In a few cases such as infills on the outfall works, 6000 psi is stated. The general mix is 7:1:0·62 whilst for the biological shield the mix is 6·5:1:0·60, giving a maximum compacting factor of 0·92. Mixes for 4500 psi concrete are 5·8:1:0·58. The mixes were designed by Dr. Barry Hughes of A.E.I.–J.T. to give optimum coarse aggregate content at lowest cost after a prolonged series of tests for this project.

The special duty of the biological shield in absorbing radiation consisting of gamma rays and neutrons calls for a very high degree of careful placing and completely effective vibration to eliminate any air pockets which might otherwise occur. Consolidated Pneumatic type 325 vibrators are used for vibrating the 39 rings, each of 3 ft lift, which form the walls of the shield. The vibrators are operated by compressed air motors housed in the vibrating head. Some 8000 vibrations are produced each minute and effective vibrating capacity is some 40–50 cu yd per hr at an air consumption of 50 cu ft per min for each vibrator, air pressure being 90 psi. Densities in excess of 150 lb per cu ft are being obtained. Vibration of a 6·5:1:0·60 mix to this density gives a most favourable radiation barrier as its relatively high density means more effective attenuation of the gamma rays per unit of thickness while the hydrogen atoms of the water, which combines with the cement, slow down the high energy neutrons for effective absorption.

Where densities of 220 lb/cu ft are required, as for example round the muffs for the control rods, barytes concrete will be used whilst investigations are being carried out on the use of steel shot for heavy concrete in connexion with the pile cap. Densities of up to 350 lb/cu ft have been gained with steel shot and much research for future reactor design has been carried out

BRADWELL POWER STATION.—These two pictures show progress in the construction of the nuclear power station at Bradwell-on-Sea, Essex, being constructed by the Nuclear Power Plant Company Limited. Above is seen the steelwork of the turbine hall, and at left the foundations and part of the structure for Nos. 1 and 2 reactors

on problems of thermal conductivity, thermal expansion and thermal stability.

Both civil contractors make use of additives. Balfour Beatty who are concerned with the turbine hall and outfall works use Febcrete, an air entraining agent giving a maximum allowable air content of 4% for their work whilst John Laing for reactor construction use Lissapol which acts as a lubricant and improves workability. Air tests are carried out at the main batching plants two or three times daily and mixer weigh mechanisms are tested every two months.

Checks are constantly carried out to ensure that only the specified amounts of additives are used. This is of particular importance on work connected with the biological shield as entrainment of air masses may occur when a surface active agent such as Lissapol is used indiscriminately. Dilution of the agent in the proportion of one pint of Lissapol to 5 gal water is carried out and the mixture is added at the rate of one pint of solution to 1 cwt cement. Febcrete, the air entraining agent used by Balfour Beatty on the turbine hall and C.W. sections of the works is used at the controlled rate of one fluid ounce per hundredweight of cement, using a mechanical dispenser.

Babcock & Wilcox Anglo-American Co-operation

Following many years of successful co-operation between Babcock & Wilcox Limited and the Babcock & Wilcox Company, of America, in the design of conventional steam-raising plant, it is announced that the two companies have now extended their technical collaboration into the nuclear power field.

Babcock & Wilcox Limited has an experience of some ten years in nuclear engineering in collaboration with the United Kingdom Atomic Energy Authority. It collaborated with the Authority in the design and construction of all the specialized steam-raising plant for the Calder Hall and Chapelcross Atomic Power Stations of the Atomic Energy Authority, and, as a member of the English Electric, Babcock & Wilcox, Taylor Woodrow, Atomic Power Group, is currently engaged in the construction for the Central Electricity Generating Board of the world's largest nuclear power station at Hinkley Point (Somerset, England).

Similarly The Babcock & Wilcox Company became involved in the American nuclear programme over ten years ago, and has co-operated closely with the United States Atomic Energy Commission on nuclear developments and has designed and constructed many pressure vessels and heat exchangers for the American programme The company is also the principal contractor for the design and supply of the pressurized-water thorium converter reactor and the steam raising equipment for the Indian Point Power Station of the Consolidated Edison Company of New York. It has, too, a contract for the supply of the complete propulsion plant for the world's first nuclear-powered merchant ship, N.S. Savannah, which incorporates a pressurized-water reactor. The company's production facilities include the first privately built factory for the fabrication of nuclear fuel elements and a laboratory for the testing of reactor cores under critical conditions.

Special TV for Atomic Power Station

A television nuclear reactor camera being made by Pye Limited will be used at the Central Electricity Generating Board's Bradwell atomic power station to help engineers inspect the interior of the station's two reactors when they come into operation during 1960.

The first of three Pye TV cameras for exclusive use in the atomic energy industry was put into operation at Calder Hall in 1956. It was 3 in. dia and 40 in. long and had its own source of illumination. A special cooling system was also provided. The second camera, which was designed hurriedly for a special purpose in 1957, led to the development of a camera which incorporates facilities for handling objects within the reactor core.

It is a camera similar to the latter which is to be delivered to the Central Electricity Generating Board some time next year.

Design Data for Equipment for the Transport of Perishable Foodstuffs. New York, 1958; United Nations. London; H.M. Stationery Office, 1/6 net (by post 1/10). 16 pp. $8\frac{1}{2} \times 11$ in.

Designers of equipment for the transport of perishable foodstuffs will find a fund of invaluable data in a United Nations publication, "Transport of Perishable Foodstuffs" which has been drawn up in co-operation with the International Institute of Refrigeration. It describes the general problem and outlines briefly the kind of containers and vehicles required, but the really valuable data are contained in a number of annexes. These give tables of figures for the loading and transport temperature for meat, fish, eggs, poultry, butter, cheese and other foodstuffs of animal origin, and of a long list of vegetables and fruits; these are for fresh products, and further similar data are given for frozen products. A list of definitions and standards for equipment is included and a simplified formula is explained for the amount of heat to be removed or supplied during transport. Two appendixes show how the theoretical thermal balance sheet for any consignment of perishable foodstuffs may be drawn up, and eight fully worked examples are given, each concerning the transport of a particular foodstuff between named places at a certain time of the year. The bulletin concludes with a bibliography.

Teaching Mechanical Engineering.—The 13th "Bulletin of Mechanical Engineering Education", published by the Manchester College of Science and Technology contains twelve contributions. R. Thomson offers a simplified approach to the problem of finding the area of a surface of irregular outline, and T. Bevan reminds his readers of how a penknife can be used as a hatchet planimeter. An instrument for summing-up the intercepts of surface finish curves is described by M. Ehrenreich who also gives particulars of an apparatus for testing the measuring force of dial indicators and comparators. In a paper, "On the Turning of Tapers", M. M. Barash confirms present-day workshop preference for the taper turning attachment for accurate work. Two contributions from Harvard University are the description of a device for the measurement of Young's Modulus and Poisson's Ratio, and of an apparatus for the measurement of γ by the method of Rüchardt and Rinkel, both by D. W. Batteau. An analogy between the flow of fluid in a pipe and of electrical current through a resistor is used by J. W. J. Wielogorski to simplify the solution of problems of fluid flow in pipe networks. The use of the cathode ray indicator in experiments with high speed internal combustion engines is described by A. J. Clark who gives details of five experiments designed to reveal certain characteristic relationships. Professor H. Wright Baker makes a plea for the abolition of "superfluous gravity" in the nurseries of science

books

and demands to be told "who was the crank who invented the abuse of 'g' and made so many nice young men look like asses ?" The bulletin concludes with the text of an address by C. E. Iliffe of the U.K. Atomic Energy Authority, on "Mathematics in Mechanical Engineering", in which he expresses more confidence in the place of mathematics in engineering than in that of mathematicians; and says that mathematics is best taught to engineering students by qualified engineers.

European Steel and Engineering.—The disappearance of a sellers' market in Europe in all but a limited range of special types of steel is remarked upon in the United Nations "Economic Bulletin for Europe" (H.M.S.O., 3/9 net), where it is recorded that in the United Kingdom, Belgium, Luxembourg and Italy, production of crude steel in the first quarter of 1958 was below the level of a year ago. In Western Germany, the rise in output has been noticeably lower than in past periods and by April production was below the level of the previous year. Only in France did crude steel output maintain its vigorous upward trend in response to the continuing buoyancy of home demand. However, while, according to the bulletin, the output of the metal-using industries is, on the whole, still well maintained, the recent decline in incoming orders gives rise to concern in some countries. Thus, incoming orders for machinery have been falling in Belgium since the autumn of 1957, and in the United Kingdom the persistent reduction of the order book for machine tools, which began some two years ago, has been increasingly influenced by the smaller flow of new orders. On the other hand, the bulletin says that there is some evidence of a strengthening of domestic demand for products of the metal-using industries in western Germany, following a period of almost two years in which the volume of fixed investment was virtually stable and the rate of expansion in this sector slowed down. Domestic orders for machinery have been coming in somewhat faster in recent months, but the increased demand in the rest of the metal-using industries is mainly for consumers' durable goods for the home market.

ASTM Standards.—To keep up to date the trienially published Book of ASTM Standards, the American Society for Testing Materials, in the intervening years, issues supplements to each part of the book. The 1957 supplements, issued in seven parts, give in their latest form 415 specifications, tests and definitions which either were issued for the first time in 1957 or revised since their appearance in the 1955 book or the 1956 supplements. The parts in order deal with ferrous metals; non-ferrous metals; cement, concrete, ceramics, thermal insulation, road materials and waterproofing; paint, naval stores, wood, cellulose, wax polishes, sandwich and building constructions and fire tests; fuels, petroleum, aromatic hydrocarbons and engine antifreezes; rubber, plastics and electrical insulation; textiles, soap, water, paper, adhesives and shipping containers. The supplements, in heavy paper covers, can be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., at $4.00 per part—or $28.00 for the complete set of seven parts.

Data for Rolling Steel.—A new technical work published by BISRA is "The Calculation of Load and Torque in Hot Flat Rolling", by P. M. Cook and A. W. McCrum. It provides a concentration of essential data not previously available and contains in essence the results of five year's work at BISRA's Sheffield laboratories in determining stress-strain curves for steel in compression at temperatures up to 1200° C, and over a range of deformation speeds usually met in working practice. It describes the method and contains the data for

calculating the load and torque for rolling twelve steels. The ninety-six large graphs give the necessary mean yield strength data for these steels at 900, 1000, 1100 and 1200° C, over a range of strain rate and reductions covering all industrial requirements. Other graphs are provided from which the strain rates and geometrical functions associated with any particular operation can rapidly be calculated. The book is obtainable from the British Iron and Steel Research Association, 11 Park Lane, London W1, price £3 5s. 0d. or $9·30, postage and packing included.

Research Bulletins.—In Bulletin No. 447 of the University of Illinois, O. M. Sidebottom and M. E. Clark present a theory by which the load and deflexion necessary to produce a given depth of inelastic deformation in an eccentrically loaded member can be rationally determined. Only the stress-strain diagrams of the material are required. The shape of web section cut-out which results in the least reduction in fully plastic load-carrying capacity per pound of beam weight is dealt with in Bulletin No. 448 by W. J. Worley. A diamond shape is arrived at. Bulletin No. 449 deals with pressure losses through forced-air perimeter fittings and supply outlets of heating and cooling systems. The authors, M. V. R. Rao, D. R. Bahnfleth and H. T. Gilkey, show that the resistance of an assembly cannot be calculated accurately by adding the resistances of the components. The bulletins are $1 each from the University of Illinois, Urbana, Illinois, U.S.A.

Measurement of Thickness.—A survey of information on the various methods and problems of measuring thickness that are frequently encountered in science and industry is given in "The Measurement of Thickness", by George Keinath, National Bureau of Standards Circular 585, 50 cents, (Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.) Measurement of physical parameters involved in the practical measurement of thickness, such as displacement, is covered, in addition to some more general aspects of the measurement, such as dynamic response. The methods are treated in seven groups, according to physical operating principles; mechanical, chemical, electrical, magnetic, optical, X-ray, and radioactive radiation. The methods and instruments are not described in detail but a discussion of ranges, accuracy, advantages and limitations is included. One section discusses thickness meters for the blind. A bibliography of references, a limited list of U.S. suppliers, and a detailed index of the gauges, methods, applications, and U.S. trade names covered are appended.

Research for Industry.—More than 1000 items of research are mentioned in the publication of this title issued by the Department of Scientific and Industrial Research, H.M.S.O., 7/6 net (by post 8/1), $1·35 U.S.A. It is impossible to give any idea of the scope, so multifarious are the activities concerned. Suffice it to say that the text is a concise statement of what each and all of the various research associations are doing. The book will obviously be useful to anyone engaged in product development or to whom an idea of the trend of things is important.

Service for Zinc Users.—An interesting illustrated booklet has been prepared by the Zinc Development Association, 34 Berkeley Square, London W1, describing the work of the Z.D.A. and giving a review of its services. Its activities are world-wide, particularly its information service to which its technical officers devote much of their time. The association sponsors research and provides a productivity service and also takes part in the preparation of standards. The associations' series of excellent publications is now some 70 in number.

Industrial Rubber.—The use of rubber powder and latex in road surfacing materials, perhaps the most important current development in highway construction, is given special attention in the report of The Natural Rubber Development Board, Market Buildings, Mark Lane, London EC3. The tendency is to use rubber in conditions which are particularly severe and where traditional materials have proved inadequate. Rubberised bitumen has also had success as a surface material for airport runways. Rubber pads for use with concrete railway sleepers have been laid in very large numbers, particularly in South Africa, Australia and New Zealand.

New Standards

Machine screws and machine screw nuts (B.S.W. and B.S.F. threads) (B.S. 450:1958) Price 12/6.

Although the Unified thread has been steadily gaining popularity since it was first introduced, Whitworth threads must inevitably continue in use for a long time to come. This new edition of B.S. 450 has been issued to meet the needs for an up-to-date standard for machine screws with B.S.W. and B.S.F. threads.

The general requirements in the present standard are in most cases similar to those in B.S. 1981 "Unified machine screws and machine screw nuts". In addition, the scope has been considerably extended to include all the various types of heads in common use in both slotted and recessed forms.

Keys & Keyways (B.S. 46: Pt. 1: 1958). Price 7/6.

Requests for larger manufacturing tolerances have resulted in the revision of B.S. 46: Part 1. The various types of keys and keyways now have, as far as possible, consistent dimensions and tolerances, thus enabling a standard range of cutters to be used for machining the various types of keyway.

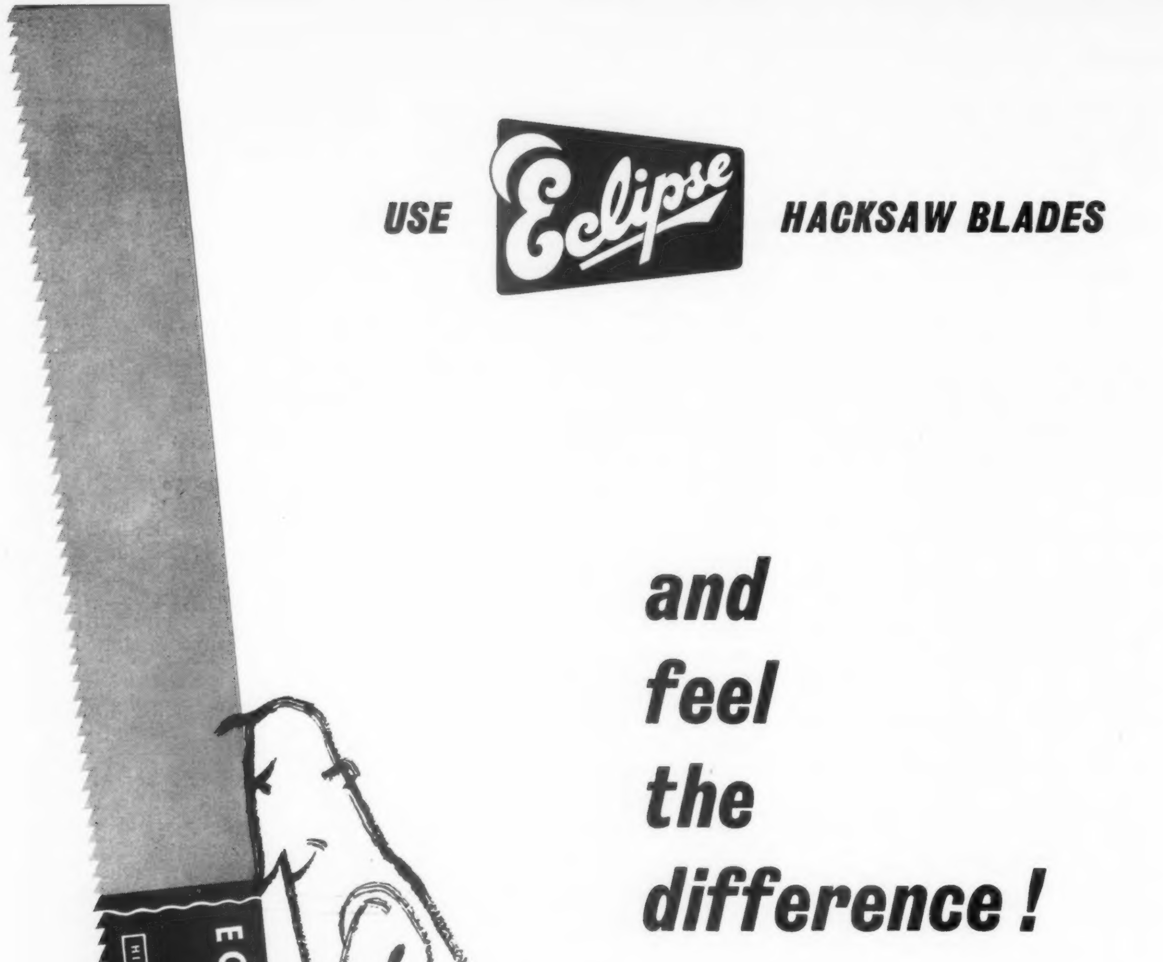
The tolerances on the width and depth of rectangular and square plain and gib-head keys have been increased. Keys of $\frac{1}{32}$ in. size have been eliminated, which has resulted in slight changes in key sizes for small shafts; for instance for shaft sizes over $\frac{1}{4}$ up to $\frac{1}{2}$ in. dia the square key size is now $\frac{1}{8}$ in. not $\frac{5}{32}$.

Details of tangential keys have again been included. The section dealing with marine tailshaft keys has been re-written and recommendations on the preferred lengths of keys have been revised and brought into line with current practice.

Manufacturers Licensed to use the Certification Mark of the Institution PD 3068 List A industrial goods. Price 2/-. PD 3089 List B consumer goods. Price 2/-.

Nearly 1500 manufacturers licensed to use the B.S.I.'s "Kitemark" on their products are included in two lists just published by the Institution. Industrial goods and consumer goods are separated into List A, and List B respectively.

British Standards Institution, 2 Park Street London, W1.


USE Eclipse HACKSAW BLADES
and
feel
the
difference !
ECLIPSE
10
HIGH SPEED STEEL

BUSINESS & PROFESSIONAL

Personal

Mr. G. P. Balfour, B.Sc., A.C.G.I., A.M.I.Chem.E., has been appointed managing director of Stockdale Engineering Limited, constructional chemical engineers of Poynton, Cheshire.

Dr. J. D. Armit has been appointed a director of Triplex Holdings Limited, which controls the Triplex Safety Glass Company Limited, of London, Birmingham and Eccleston, and the Triplex group's chemical-glassware and engineering subsidiaries, including Quickfit & Quartz Limited, Q.V.F. Limited, Weldall & Assembly Limited, and Stern & Bell Limited. Dr. Armit, formerly a director of ICI and wartime Director-General of Explosives at the Ministry of Supply, has for some years been consultant chemist to the Triplex Group, working in association with Dr. A. C. Waine, research director of the Triplex Safety Glass Company Limited.

Mr. P. S. Beale has been appointed a director of The British Oxygen Company Limited. Mr. Beale was formerly chief cashier, Bank of England, and recently general manager of The Industrial Credit and Investment Corporation of India Limited, Bombay. **Mr. R. J. Barritt** has been appointed chief executive, B.O.C. engineering division.

C.A.V. Limited, Acton, London W3, announce the following staff changes: North-Eastern Area. **Mr. W. H. Simpson** is now area manager with headquarters at Leeds. This area embraces the Newcastle-on-Tyne area, where **Mr. T. A. Beckett** remains in charge of service matters as before. North-Western Area. **Mr. M. J. Reynolds** is area manager with headquarters at Liverpool. This area embraces Manchester, where **Mr. J. E. Mangnall** is area sales manager. South-Western Area. **Mr. R. H. Lewis** is area manager with headquarters at Bristol. Central & South Wales Area. **Mr. D. Brown** is area manager with headquarters at Cardiff.

Mr. W. Clark, works director of the John Bull Rubber Company Limited, has been appointed to the board of Metalastik Limited.

Gamet Products Limited, Hythe, Colchester, Essex, manufacturers of Micron precision taper roller bearings, announce that **Mr. J. Betts**, formerly of Taylor, Taylor & Hobson Limited, has joined their staff as technical sales engineer. He will cover the Midland Area and will operate from 54 Hidcote Road, Oadby, near Leicester.

E.M.I. Electronics Limited announce the appointment of **Mr. K. Elphinstone, M.B.E.,** as export manager following **Mr. R. W. Addie's** recent appointment to the board as marketing director.

Mr. R. T. Hayes has been appointed a director of United Coke and Chemicals Company Limited, a subsidiary of The United Steel Companies Limited. Mr. Hayes is commercial manager of United Coke and Chemicals, and of United Steel's Ore Mining Branch and the Santon Mining Company Limited.

Mr. P. W. Faulkner, O.B.E., general manager of the chemical and metallurgical division of The Plessy Company Limited since 1953, has been appointed a director and general manager of Plessey International Limited. His successor at the company's Towcester plant will be announced shortly.

Martonair Limited announce the appointments of three new technical representatives: **Mr. M. E. Pugson** has been appointed to territory comprising Devon, Cornwall, Somerset and Dorset. **Mr. L. Higginbottom** has been appointed territory South-West of London, bounded by Worthing, Bognor, Basingstoke, Wokingham and Richmond. **Mr. J. J. Westwood** has been appointed territory bounded by North West Birmingham, Stoke and Shrewsbury.

Siemens Edison Swan Limited announce further appointments in their cable divisions. **Mr. R. G. Holland, A.M.I.E.E.** has been appointed assistant cable sales manager, special contracts. **Mr. R. B. Tucker** has been appointed assistant sales manager, rubber and plastic cable division.

Dr. W. Angus Macfarlane was recently appointed managing director of the National Industrial Fuel Efficiency Service. This appointment reflects the high degree of acceptance by industry generally of the work of N.I.F.E.S., which it will be recalled became operational in May 1954 as a non-profit-making organisation. Prior to joining N.I.F.E.S. in February 1954 as its chief executive, Dr. Macfarlane was scientific attaché at the British Embassy and head of the United Kingdom Mission in Washington.

Mr. W. J. Gaffney has been appointed chief engineer for all their production plants in Great Britain for the Goodyear Tyre & Rubber Company (Great Britain) Limited. He was formerly manager of engineering and maintenance at the Wolverhampton plant—a position which **Mr. R. E. Ward,** from Akron, recently took over.

Dr. J. B. Higham has been appointed to the new post of head of technical development by Pilkington Brothers Limited, the glass manufacturers. He will be responsible for the creation of a centralised department to co-ordinate and expand technical development in all the company's works.

Mr. Colin L. G. Baker has recently been appointed a director of George Angus & Co. Limited. He has been secretary and financial controller of the company since 1950.

Dr. W. F. Watson has been appointed director of the Research Association of British Rubber Manufacturers. He will take up his duties at R.A.B.R.M.'s headquarters at Shawbury, Shropshire, in November, after a lecture tour in the United States. Formed in 1919 the Association now has a staff of 90 and about 250 member firms. Its present director, **Dr. J. R. Scott,** has been with the association for 35 years.

Mr. John B. Shaw, sales engineer with the Huddersfield office of Brook Motors since 1953, is transferring to the Leeds sales office in a similar capacity. He will replace **Mr. H. Lumb** who is shortly taking up another appointment with the company.

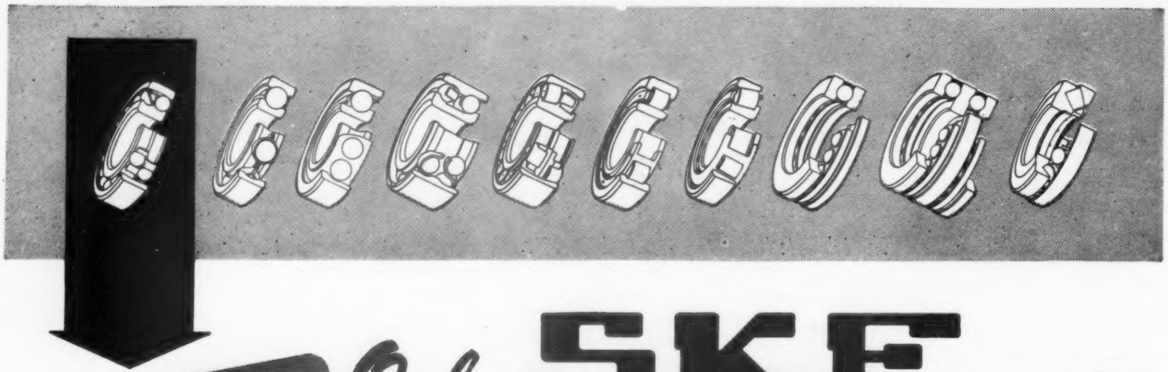
Now that the organization of the Indian Steelworks Construction Company Limited is fully established, **Mr. R. J. Barritt** resigned as managing director on the first of this month in order to return to company work. He will, however, be available to the board of ISCON for consultation. He is succeeded as managing director by **Mr. W. S. Hindson,** former chief engineer. The Indian Steelworks Construction Company Limited (ISCON) is a consortium of 13 leading engineering and electrical manufacturing companies in Great Britain formed to build for the Government of India the Durgapur Steelworks in West Bengal.

Mr. A. W. Field, B.Sc., F.B.I.M., A.M.I.Mech.E., has been appointed deputy managing director of Mawdsley's Limited, Dursley.

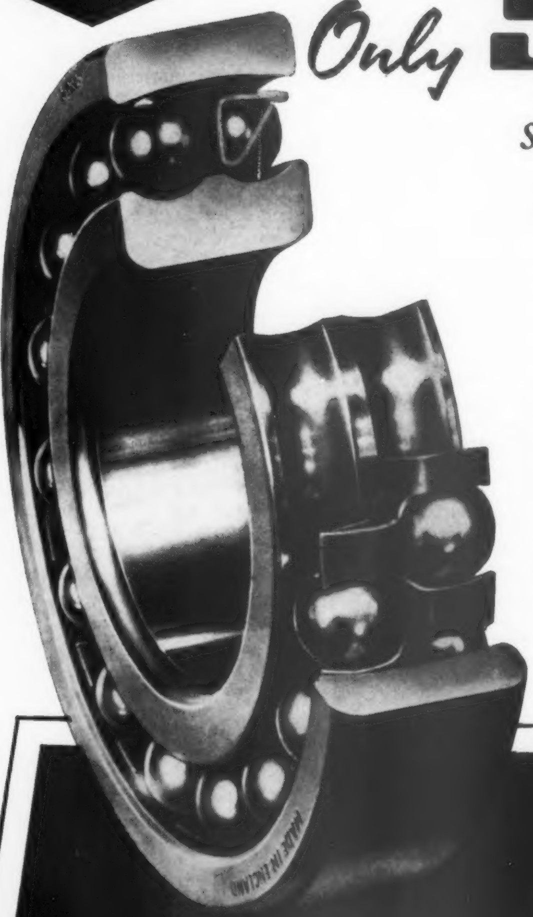
The Board of Trade announce that the **Earl of Halsbury** will retire from the position of managing director of the National Research Development Corporation on March 31, 1959, to take up another appointment.

Mr. Brian Skelton has been appointed depot manager at the Cambridge Depot of Kerry's (Great Britain) Limited. Mr. Skelton was formerly at the Stratford, Ipswich and Middlesbrough depots.

Mr. Robert Young, B.E.M., has been appointed chief inspector of the Salterpack division of Geo. Slater & Co. Limited, of West Bromwich. Mr. Young has had wide experience in the pre-packaging industry both with the Ministry of Supply during wartime and with private concerns.

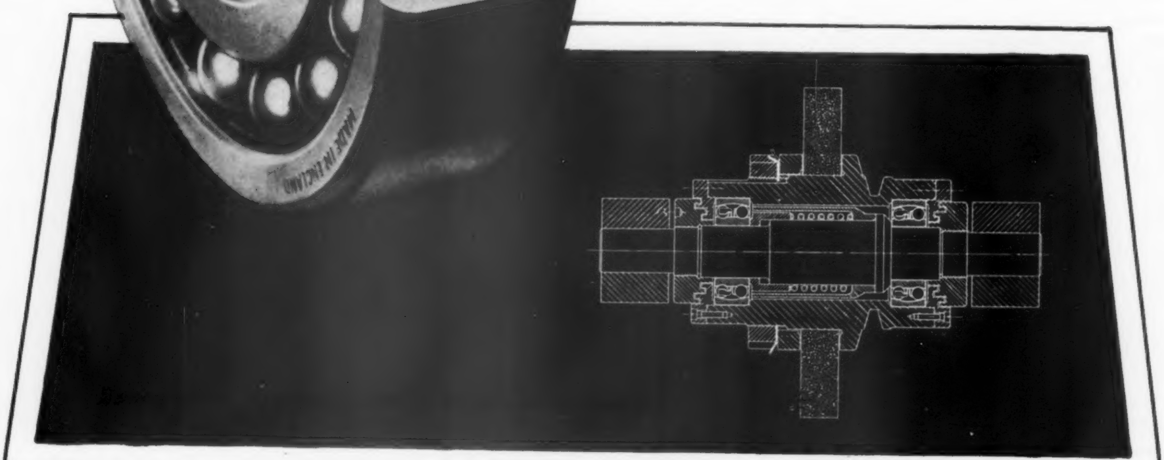


Only SKF *can offer such a wide selection of British made bearings*



The double-row self-aligning ball bearing, with its two rows of balls having a common sphered track in the outer ring, is completely self-aligning, and permits automatic adjustment to minor angular displacements of the shaft. Bearings of this type are particularly suited to applications where the speed is high and extra true running is required.

As the only British makers of all four basic bearing types—ball, cylindrical roller, taper roller and spherical roller—The Skefko Ball Bearing Co. Ltd. can offer comprehensive and unbiassed technical information on all bearing problems.



THE SKEFKO BALL BEARING COMPANY LIMITED · LUTON · BEDS

THE ONLY BRITISH MANUFACTURER OF ALL FOUR BASIC BEARING TYPES: BALL, CYLINDRICAL ROLLER, TAPER ROLLER AND SPHERICAL ROLLER

THE BRITISH THOMSON-HOUSTON COMPANY Limited announce that **Mr. W. J. Carfrae, B.Sc.Eng.), M.I.E.E.**, has been appointed assistant chief electrical engineer of the company.

The following further appointments to the newly-formed A.E.I. Heavy Plant Division, managed by the British Thomson-Houston Company, are announced: **Mr. I. A. Ferguson, M.I.E.E.**, manager, large electrical machine sales; **Mr. P. S. Clayton, B.Sc.**, manager, power rectifier sales; **Mr. J. B. Siddaway, B.Sc.**, manager, compressor sales.

Mr. F. Gordon Kay, A.M.I.Mech.E., has been elected to the board of Acheson Colloids Limited. Formerly sales manager of that company, he was promoted in 1957 to the position of manager, Sales Relations of Acheson Industries (Europe) Limited, the parent body for Acheson Colloids Limited, Acheson Dispersed Pigments Company, and Acheson Colloiden N.V. of Holland. Mr. Kay has been with the Acheson organisation for 34 years.
Other appointments announced by Acheson Colloids Limited are those of **Mr. G. F. Henderson,** promoted assistant sales manager, based at the Richmond office; **Mr. T. Wint,** appointed sales engineer, operating from the Rochdale office; **Mr. A. Cheney,** promoted sales manager. **Mr. G. J. B. Davies,** appointed general manager of Acheson Dispersed Pigments Company, Dukinfield, Cheshire. This company, which specialises in the processing of pigments into synthetic resins, plasticisers and other media, is a division of Acheson Industries (Europe) Limited. Mr. Davies was previously general manager of Acheson Colloiden N.V., Scheemda (Gr.), Netherlands; **Mr. Edward A. Smith,** promoted assistant manager, European Operations. This senior executive position carries the responsibility of maintaining efficiently all operations of the various production units of Acheson Industries (Europe) Limited in Britain and the Continent.

Mr. W. E. J. Cross, general manager of Joseph Batson & Co. Limited, has been elected to the board and appointed managing director.

METROPOLITAN-VICKERS ELECTRICAL COMPANY Limited recently appointed **Mr. H. G. Bell, M.Sc., M.I.E.E.**, as consulting engineer, instrument and meter department, the appointment following Mr. Bell's retirement as chief engineer, North Western Electricity Board.

Mr. J. R. Munro, director of manufacturing and acting manager of Caterpillar Tractor Company Limited's new Glasgow plant, has been elected a vice-president of the parent company in Peoria, Illinois, and will assume administrative responsibility for the activities of its manufacturing division.

VICKERS LIMITED announces the following changes in group organisation: **Mr. E. J. Waddington** has been granted sick leave until December 31, 1958, when, on reaching normal retirement age, he will retire from his offices of director of finance of Vickers Limited and of Vickers-Armstrongs Limited and also from the boards of directors of those two companies. **Mr. R. P. H. Yapp** will carry out Mr. Waddington's duties as director of finance. **Mr. B. L. Snow** has been appointed sales manager of Vickers-Armstrongs (Engineers) Limited and a special director of that company with effect from July 1, 1958, relinquishing his appointment as sales director of George Mann & Co. Limited. **Mr. T. Wood** has been appointed to the board of George Mann & Co. Limited and to the office of sales director of that company with effect from July 1, 1958. **Mr. Glyn Jenkins** has been appointed to the sales staff of Bowmaker (Plant) Limited. **Mr. H. Crewe Horobin** has been appointed branch manager at the Cardiff depot and **Mr. Derek Leeks** has been appointed representative for the Derbyshire area.

Sir Frederick Neill, chairman and managing director of James Neill & Company (Sheffield) Limited, on the occasion of the investiture at Buckingham Palace in the Order of Knighthood. With Sir Frederick is Lady Neill and also Mr. J. Hugh Neill, deputy chairman of the company

THE retirement of **Mr. Edwin Barnard,** for many years manager of the excavator department of Ransomes and Rapier Limited, on June 30 was marked by a presentation ceremony.

Mr. F. Foster, M.Sc., A.M.I.E.E., was appointed in June last managing director of Crompton Parkinson (Stud Welding) Limited, a recently formed subsidiary company of Crompton Parkinson Limited.

Mr. R. Scholey has been appointed superintendent of the Ickles departments of Steel, Peech and Tozer, a branch of The United Steel Companies Limited. Formerly assistant superintendent, Mr. Scholey succeeds **Mr. N. H. Bacon** who has retired after 47 years' service. **Mr. D. R. Baker** has been appointed assistant Ickles superintendent (technical) and **Mr. D. B. Bray** becomes manager of the heat treatment department.

Mr. O. Page, assistant works metallurgist (light departments) of Samuel Fox & Co. Limited, a subsidiary of The United Steel Companies Limited, has been appointed deputy chief inspector. Mr. Page takes up his new position this month, and **Mr. W. Jackson** succeeds him as assistant works metallurgist (light departments).

Obituary

WE regret to record the death of **Mr. John Pickthall,** Compoflex group sales manager, killed in a motor car accident on July 17, 1958, at the age of 48. Mr. Pickthall joined Compoflex after the war as a representative, was later northern area manager and subsequently home sales manager.

Addresses

THE address of the Nottingham branch of Crompton Parkinson Limited is now Crompton House, Maiden Lane, Woolpack Lane, Nottingham. Tel. Nottingham 45678.

LEYLAND BELGIUM S.A., agents for Leyland Motors Limited in Belgium, have changed their address and are now situated at 18 Avenue de Saio, Anderlecht, Brussels.
THE telephone numbers of the Sheffield depot of Leyland Motors Limited have been altered and are now: Sheffield 348827-8-9.

THE name of A. D. Tack Rags and Adhesive Dusters Limited has now been changed to Anti-Dust Services Limited, in order to embrace the wider activities of the company, as a result of the considerable developments that have taken place since its formation. The address of Anti-Dust Services Limited remains as before, at Stafford Street, Dudley, Worcs (P.O. Box No. 28).

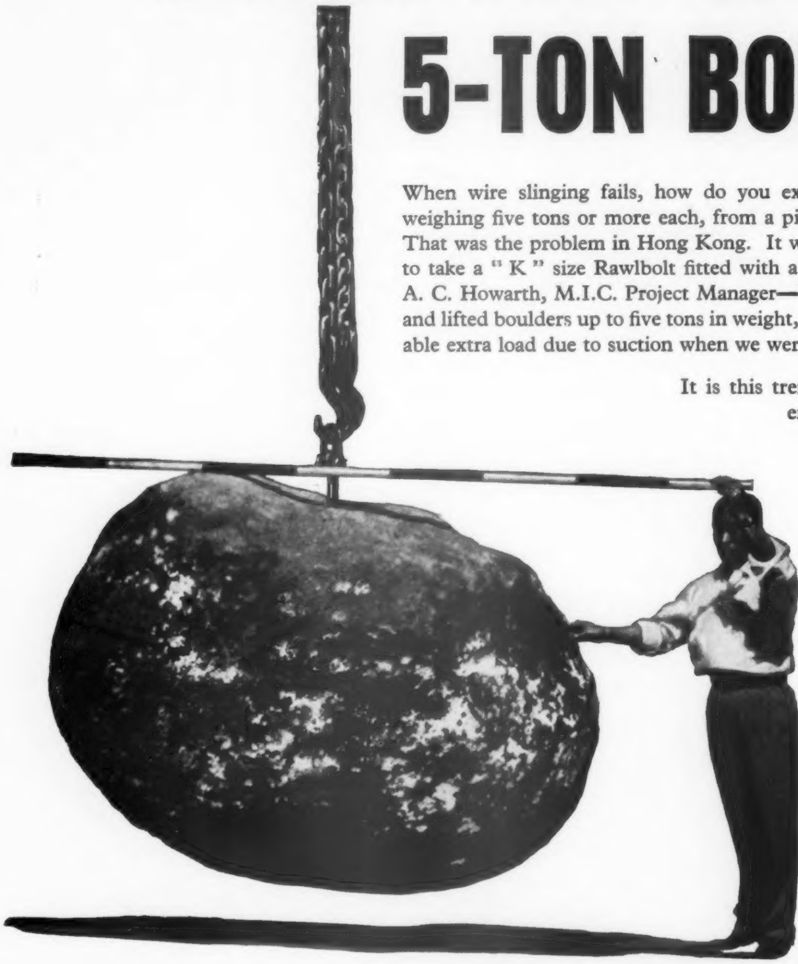
EVODE LIMITED are moving their London office to 82 Victoria Street, London SW1, the telephone number remaining as before, ABBey 4622.

KELVIN & HUGHES (INDUSTRIAL) LIMITED have moved their administrative offices from 2 Caxton Street, Westminster, London SW1 to their new building at Empire Way, Wembley, Middlesex, telephone WEMbley 8888; telegraphic address: Kelhue, Wembley.

FIELDEN ELECTRONICS LIMITED, Wythenshawe, Manchester, have established a permanent Midland area office in Walsall, under the management of Mr. F. Bernard Price. The address is: 51 Bradford Street, Walsall, Staffs. Telephone No. Arboretum 55343.

J. W. ROBERTS LIMITED have now moved their headquarters from Armley, Leeds,

RAWLBOLTS LIFT 5-TON BOULDERS



When wire slinging fails, how do you excavate round granite boulders, weighing five tons or more each, from a pit 12 ft. square and 20 ft. deep? That was the problem in Hong Kong. It was solved by drilling the granite to take a " K " size Rawlbolt fitted with a 1" diameter eyebolt. Says Mr. A. C. Howarth, M.I.C. Project Manager—" This device proved invaluable and lifted boulders up to five tons in weight, even though there was considerable extra load due to suction when we were getting down to the sandbed."

It is this tremendous *grip* of Rawlbolts that ensures safety in any bolt-fixing job, large or small.

We are indebted to Messrs. George Wimpey & Co. Ltd., the Building and Civil Engineering Contractors, for the above information. The photograph was kindly provided by Mr. Howarth from the North Point Generating Station, Hong Kong.

"Ask on your trade card or letter paper for free copy of Rawlplug TECHNICAL DATA SHEET folder R1519 which has been specially designed for gentlemen of the Drawing Board. An invaluable source of reference for dimensions, loads, weights, etc., of Rawlplug Fixing Devices."

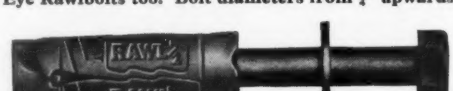
Fixed in minutes

Rawlbolts grip by *expansion.* You drill the material, insert the Rawlbolt, tighten up. The job is ready to take its full load *at once*—no grouting in, no waiting for cement to harden. A Rawlbolt fixing is made in only a fraction of the time taken by any other method.

Write now for free technical literature, and file it for quick reference when your next bolt-fixing job turns up.

SIZES & TYPES FOR EVERY PURPOSE

For bolting down machines and heavy plant, use the Loose Bolt Rawlbolt—inserted after the machine is slid into position; for wall-fixings, the Bolt Projecting Rawlbolt. There are Rawlbolts for supporting pipework and for use with pipe hangers, and Hook and Eye Rawlbolts too. Bolt diameters from ¼" upwards.



RAWLBOLTS

For Speed and Strength!

THE RAWLPLUG CO. LTD. RAWLPLUG **CROMWELL RD., LONDON, S.W.7**

B.581

into their new modern building at Chorley New Road, Horwich, Bolton, Lancashire, telephone Horwich 840 (7 lines); telegrams, Special, Horwich Bolton-Telex. Telex No. 63133. The Ferobestos department and the general sales department will be housed in the same building.

Designing in Plastics

WITH a view to encouraging young designers in plastics, the Worshipful Company of Horners—one of the oldest City companies which today embraces members of one of the youngest industries, the plastics industry—have been awarding prizes for the best designs entered in an annual competition, organized by the British Plastics Federation. In previous years, the award, of up to 50 guineas, was sometimes divided between several entries, but this year it has been decided to have only one prize, which will be presented to the winner at a dinner of the Worshipful Company of Horners to be held in an ancient City livery company's hall in London. The competition is open to anyone resident in Great Britain and Northern Ireland, not over 30 years of age on September 30, 1958, and leaflets giving details of the regulations have been issued to art schools and colleges all over the country.

New Metallizing Company

VACUUM METALLIZING PROCESSES LIMITED, a new company, registered in England, has been formed by Continental Can Company Inc. of New York and Vacuum Research (Cambridge) Limited of England, for the purpose of promoting and licensing in all territories outside North and South America their jointly developed and patented process for the metallizing in vacuum of plastic films and paper, on a commercial basis. Vacuum Research (Cambridge) Limited has been responsible for the design, construction and installation of production metallizing facilities now operated by Continental Can Company Inc. and their licencees in the U.S.A.

Goodyear New Division

A NEW division, to be known as the engineering products division, has been formed by the Goodyear Tyre Rubber Company (Great Britain) Limited, to take over the further development, manufacture and testing of Goodyear industrial disc brakes and Goodyear ausco double-disc brakes which have hitherto been handled by the aviation products division. A further function of the division is the handling of contract work.

Winston's New Agency

WINSTON ELECTRONICS LIMITED have been appointed distributors in Great Britain of the Beckman-Berkeley (Richmond, California, U.S.A.) range of electronic equipment for industry. The new American factory now being built in Scotland, of which Mr. J. R. McNally is the general manager, will manufacture much of the equipment for Britain and the Euromarket. Because of the specialized range of the Beckman-Berkeley equipment, A. Gallenkamp & Co. Limited have, by agreement, with Winston Electronics Limited, and Beckman's, arranged to take over the sole agency for Beckman process control instruments.

New C. & G. Course in Engineering Drawing

BEGINNING with the 1958-59 session is a new scheme of training in mechanical engineering drawing for engineering apprentices who have followed N.C. courses to S.3 level and who wish to become draughtsmen. Full particulars may be obtained from the director of the City and Guilds of London Institute, Gresham College, Basinghall Street, London EC2. Enquiries should be marked "B.5". Syllabuses in certain other engineering craft subjects have been revised.

Uddeholm New Division

UDDEHOLM LIMITED (the British associates of Uddeholms AB, the Swedish mine-owning and steelmaking concern) have inaugurated a tool division under the managership of Mr. A. H. Mills, A.M.I.Mech.E., A.M.I. Prod.E. with headquarters at Crown Works, Northwood Street, Birmingham 3. (Telephone: CENtral 8971. Telex: 33/151). It will be concerned with the sale and development of small tools as used in production engineering, with particular emphasis on the application of Uddia brand hard metal in such components as tips, tools, dies, rolls, tube mandrels, sand blast nozzles and wear-resisting parts.

Landis Machine-Maiden Limited

AN amalgamation of British and American threading equipment manufacturers produces a new British company, Landis Machine-Maiden Limited, operating from Hyde, Cheshire, England. Maiden & Co. have been established in Britain for over 90 years, whilst Landis Machine Company of Waynesboro, U.S.A., are producers of machines and equipment for thread cutting and thread rolling, having a reputation built up over the past 55 years.

Leyland New South African Agents

As a result of an agreement between Leyland Albion (Africa) Limited and Rauhs Diesel Service (Pty) Limited of Upington, more extensive sales and service facilities will be available for Leyland, Albion and Scammell vehicles. The new agents will serve the Gordonia, Kenhardt and Prieska territories.

Contracts and Work in Progress

E. P. ALLAM & CO. LIMITED (member of United Construction Machinery Company Limited of West Drayton).—Concrete vibrating and finishing equipment—including 16 Tampactors Mark II—to the value of over £5,000, for the East German Government (through D.I.A. Maschinen Export in East Berlin).

IGRANIC ELECTRIC COMPANY LIMITED, Bedford.—Centralized motor control panels and auxiliary control boards for a freezing plant value £50,000 for Alliance Freezing Company (Southland) Limited, in Invercargill, New Zealand.

WILD - BARFIELD ELECTRIC FURNACES Limited, Watford, Herts.—Twenty-eight induction heated aluminium holding furnaces for U.S.A., valued at nearly $300,000.

EDGAR ALLEN & CO. LIMITED, Sheffield.—Supply and installation of dockrail at Mombasa Harbour, the first dockrail section to be supplied in Africa.

HEENAN & FROUDE LIMITED, Worcester.—Tyre test plant for North British Rubber Company of Edinburgh and similar plant for Frances Shaw Limited of Manchester as part of a consignment of tyre-making equipment for Yugoslavia.

WOODALL-DUCKHAM CONSTRUCTION COMPANY Limited.—Erection of first Shell Gasification Process plant for South Eastern Gas Board at the Isle of Grain. Estimated cost £3m.

TAYLOR WOODROW CONSTRUCTION LIMITED.—Contract for the production of ½ million tons of opencast coal for N.C.B. at Aberdare.

SIEMENS EDISON SWAN LIMITED.—Seven automatic telephone branch exchanges using high-speed motor uniselectors for South African Railways. Also 1,000 Siemens-Ediswan Centenary Neophone instruments for Hull Corporation independent telephone system.

TILGHMAN'S LIMITED, Altrincham.—Shot blasting machine, Cowlairs Works, Glasgow, for British Railways.

STANDARD TELEPHONES AND CABLES Limited, London.—Cabling of telecommunications and supervisory circuits, Airdrie-Helensburgh line and associated branches, for British Railways.

METROPOLITAN VICKERS - GRS LIMITED, London.—Electric colour-light signalling, Kelvinhaugh-Dalmuir Park via Clydebank Central, for British Railways.

BRITISH ELECTRICAL ENGINEERING COMPANY Limited, Loughborough.—124 main line diesel-electric locomotives incorporating BTH traction equipment, for British Railways.

Trade Literature

Electric Motors and Control Gear

Five new publications have been issued by The English Electric Company Limited, Stafford. ES/134 describes the English Electric motor controller which provides uni-directional speed control of either a 2 hp or 3 hp d.c. motor supplied from a.c. mains. ES/133 describes their ½ hp Magamp motor control unit which provides a robust and inexpensive method of controlling a d.c. motor from an a.c. supply, either for speed or tension control with the inherent advantages associated with d.c. motors fully retained. DM/239 describes the B.S.D. ventilated motors. The range of 'C' motors includes outputs from ½ to 50 hp, in which advantage has been taken of class 'E' insulation. Part of the range is interchangeable with the latest American NEMA dimensional frames. FG/138 describes the Red Spot heavy duty fuseboard, for industrial purposes. Finally FG/134 describes open type sub-station fusegear. The UJ44, U35, CJ46, and Skeltag types described, are primarily intended for the protection of feeder and distributor cables on public supply networks.

Bright Nickel Plating Process

A new process for bright nickel plating to be known as the Plusbrite process is announced by Albright & Wilson Limited. This process was originally developed in the United States by the Hanson-Van Winkle-Munning Co., where it is known as Nickel-Lume and Levelume.

Major advantages of the new process are the excellent levelling properties provided together with the fully bright deposit which has a very good degree of ductility. The deposit has an attractive white colour which is also highly receptive to subsequent chromium plating operations.

Data sheets are available and further details of the process can be obtained from the Metal Finishing Department, Albright & Wilson (Mfg.) Limited, 1 Knightsbridge Green, London SW1.

Dispersal Polymer PTFE Hydraulic Hoses

Claimed to be the first British-made dispersion polymer PTFE hydraulic hoses 'Palmer Fluoroflex', manufactured by Palmer Aero Products Limited, Herga House, Vincent Square, London SW1, are suitable for use in aircraft, guided missiles and in many branches of the chemical, engineering and allied industries. The Palmer Fluoroflex assemblies, constructed from a new fluorocarbon resin compound with exterior stainless steel wire braid, will carry a wide range of engineering solvents, hydraulic fluids, acids, and H.T.P. They are completely unaffected by all chemicals except molten alkali metals and fluorine at elevated temperatures and pressures; operate in pressure-ranges from 1000/10,000 psi; withstand temperatures from -100 to $+500°$ F, are non-ageing, non-flammable, water repellent and able to withstand prolonged flexing and vibration.

Electro-lifting Magnets

A well produced catalogue published by W. E. Burnand & Sons Limited, Duo Works, Shoreham Street, Sheffield features their Phoenix circular and bi-pole electro-lifting magnets. The latter are designed for lifting billets, ingots and metal sections either hot or cold up to 4-ton in weight.

Weld-cleaning Fluid for Stainless Steels

A new weld-cleaning fluid for use with stainless steel and certain high chromium and nickel alloys is now being marketed by North Hill Plastics Limited of Manley Court, Stoke Newington High Street, London, N16.

The liquid designated Pelox is applied to the discoloured areas and the metal immediately polished with a rotating stainless steel brush. The result is a rapid removal of the discolouration leaving a bright matt finish. The makers claim that 2 pints will clean over 2000 ft of weld at a cost of about 1/3 penny per ft. Additional advantages claimed are freedom from continued corrosive attack, because the liquid is self neutralising and an indefinite storage life.

Manufacturers and Exporters in Holland Buvoha Trade Letter 1958

Copies of Buvoha Trade Letter 1958, an annual publication containing a classified list of addresses of numerous manufacturers in the Netherlands is available free of charge to all firms interested entering into business negotiations and markets in the Netherlands. Enquiries should be addressed to the Commercial Intelligence Office, Dept. Buvoha Trade Letter, Amsterdam C. (Holland), 16 Oudebrugsteeg.

Process Heating Data

The second edition of Process Heating Data, a useful handbook for the heat treatment engineer has now been published by the Process Heating Department of The General Electric Company Limited, Magnet House, Kingsway, London WC2. Besides cataloging the extremely wide range of G.E.C. products which cover every branch of heat treatment the book is arranged so that facing pages provide a fund of useful tables of equivalents, constants steel compositions cable ratings and welding data. The equipment and data are listed under separate indexes, and the book is handsomely bound in blue cloth.

Wiring Accessories and Circuit Breakers

A fully illustrated catalogue published by J. A. Crabtree & Co. Limited, Lincoln Works, Walsall, Staffs features their extensive range of electric wiring fittings and accessories. The contents includes surface and flush mounted switches, flush boxes, socket-outlets and plugs, lampholders, indicator units, and miniature circuit breakers. Every item is well displayed and price listed.

Alfa-Laval/De Laval 75th Anniversary

A souvenir brochure has been issued to celebrate the 75th anniversary of the formation of the Alfa-Laval/De Laval Group of Companies, who are manufacturers of farm and factory dairy machinery, centrifugal separators for oil and other liquids and a vast range of engineering products including heat exchangers, stainless steel pumps, textile machinery, car body pressings, washing machines and agricultural machinery.

The parent concern, the Separator Company, Stockholm, was formed in 1883 to exploit Dr. Gustav De Laval's invention of the first continually operating cream separator. From these early beginnings there has developed a world wide organisation with factories throughout Europe, North and South America and the British Commonwealth.

The British Alfa-Laval organisation has factories at Great Western Road, Brentford, Middlesex and Cwmbran, Monmouthshire.

Ferro Alloys and Metals Publications list.

A comprehensive list of technical publications on ferro-alloys and metals which is available, free of charge, to interested companies and individuals, has been prepared by the Alloys Division of Union Carbide Limited, 103 Mount Street, London W1. Their library is extensive, and includes numerous booklets on production, properties, fabrication and uses of alloy steels and irons.

Surform Files and Planes

Four new Surform tools have been introduced by Simmonds Aerocessories Limited, Treforest, Glamorgan, manufacturers of the Surform file and the Surform plane. The Surform block plane (No. 111) has a fine cut blade which gives an excellent performance when used for quick, one-handed smoothing of edges, and small surface areas, especially in awkward places. The Surform fine-cut file (No. 102) is designed to give a smooth clean cut on mild steel and other tough materials. The Surform convex plane (No. 105) is a fine cut tool of particular value for spot trimming and smoothing metal bodies in the car industry. It is also invaluable to the general building and boat-building industries. The Surform half-round

file (No. 103) gives fast and first class results on concrete surfaces.

Miniature Relays

A new range of miniature relays, has recently been introduced for both home and overseas markets by Londex Limited, Anerley Works, 207 Anerley Road, London SE20.

The items shown in List 178 include types LOK and SMM.

The LOK relays are suitable to replace non-plug-in relays, i.e., indication and alarm panels where relays can be changed easily and speedily.

Electronics in Industry

A useful guide to industrial electronics control has been produced by the British Thompson-Houston Company, Rugby to give a general impression of the range of BTH electronic control equipment which is available. Sections cover the use of electronic instruments and relays, the equipment and methods used in welding control, electronic heating, motor control, Ward-Leonard drives, machine tool control and voltage regulators and communication equipment. Much useful information is stated in simple terms.

Battery Pallet Truck

A compact and easily handled pedestrian electric battery pallet truck, with manual or power operated hydraulic pump and ram has been designed by Wessex Industries (Poole) Limited, West Street, Poole, Dorset. The power unit is completely enclosed and comprises a fabricated housing, carrying the motor with automatic brake on the armature, reduction gearing, controller, three-stud ball bearing wheel hub, taper roller bearing steering head, driving a detachable 10×3 bonded solid rubber tyred wheel.

New Factories

Bishop Auckland. Clarendon Motors Limited. To erect garage, workshop, offices and showrooms at North Bondgate. Builders, G. Stephenson, Chester Road.

Blaydon (Co. Durham). The Consett Iron Company Limited are building a 10,000 sq ft factory building near Scotswood Bridge. Builders, Alston Limestone Company Limited, Westgate Road, Newcastle upon Tyne.

Eaglescliffe (Co. Durham). Dowsett Engineering Construction Limited, Tallington, Stamford, Lincolnshire. To carry out industrial developments for the making of concrete units on a site of about 75,000 sq ft.

Felling (Co. Durham). The Wardley Service Station, Sunderland Road, Felling, plan the erection of a single-storey building to accommodate service bay, showrooms, offices, restaurant, kitchen, etc., and two-storey dwelling-house. Outline proposals approved.

Gateshead. Ridley Engineering Limited, Bensham Road. To erect offices and workshops in Albany Road.

T. Mitchison Limited, Friars Goose, Gateshead. Plans approved for developments at the slipway.

Hebburn. A. Reyrolle & Co. Limited. The Demolition and Construction Company Limited, Queen Street, Newcastle upon Tyne have received the contract for the construction of a toolroom (30,000 sq ft). Architects, Cackett, Burns Dick and McKellar, 21 Ellison Place, Newcastle upon Tyne.

Jarrow. Consett Iron Company Limited. The contract for the construction of an amenities block has been let to Leslie and Company, Woodland Road, Darlington. Architects, Tarren and Caller, 16 Great North Road, Newcastle.

Middlesbrough. Union International Company Limited, London, are negotiating for the purchase of land for the erection of a meat works (slaughterhouse, chilling room, sales hall, and ancillary departments).

Newcastle upon Tyne. Thomas Hedley and Company, City Road. To extend their factory in St. Mary's Street.

North Shields. Tyne Improvement Commission, Bewick Street, Newcastle upon Tyne, have accepted the tender of William Bain & Co. Limited, Coatbridge, Scotland, for the erection of wagon repair and platers' shops at the Albert Edward Dock.

Stanley (Co. Durham). Pinkham & Co. Limited. Plans are being considered for a glove factory of about 8,000 sq ft. Architects, Marshall and Tweedy, 36 Blackett Street, Newcastle upon Tyne.

Sunderland. R. Bartram and Sons. Plans have been approved for a plumbers' shop 115 ft long at South Dock.

Whickham (Co. Durham). British Insulated Callender's Cables Company, Leicester Square, London WC2. To erect store sheds, gantry, etc., at Cross Lane, Dunston.

Acton. Decra Limited, 28 Hanbury Road, London W3. To erect new factory on the new South Acton industrial estate.

Dayton Cycle Company Limited, Dayton Works, Park Royal, London NW10. New factory.

Arbroath. Wm. Sword Limited, Groveside Bakery, Airdrie. Plans approved for new factory at Keptie Road, Gallowden Road.

Ayr. Wallacetown Engineering Limited, 62 Viewfield Road. To extend their factory in Heathfield Road.

Basildon. Acadex Engineering Company Limited, Honeywood Road. Extensions estimated to cost £50,000. Architect, M. Tweddell, Gifford House, London Road, Bowers Gifford.

Bath. John Hygate (Bath) Limited, gear manufacturers, Monmouth Place. New factory and offices to be erected in Lower Bristol Road. Architects, Gerard, Taylor & Partners, 4-5 Bridge Street.

Birkenhead. Rediffusion (Merseyside) Limited, 58 South Road, Liverpool. To make extensions to engineering shops.

Blantyre. Turner Brothers (Birmingham) Limited. To build new factory for the manufacture of jigs, fixtures and tools, etc.

Carlisle. Porter Engineering Company Limited, Durranhill Trading Estate. Works extensions. Contractors, Michael Thompson Limited, St. Ninians Road.

Croydon. Carrington Manufacturing Company Limited, Sanderstead Road. Works extensions.

Edinburgh. Weston Biscuit Company (Edinburgh) Limited. Permission received for extensions to the factory at Sighthill.

Falkirk. Scottish Tar Distillers Limited, Lime Wharf Chemical Works, are to erect new plant.

Glasgow. Mavor & Coulson Limited. New factory at Bridgeton at an estimated cost of £600,000. Architect, J. B. Wingate, Wellington Street.

Lynn Proofing Company Limited. Extensions to works in Amulree Street, London E2.

Gosport. E. S. Perry Limited, Fareham Road, Bridgemary. The contractors for extensions to the works are F. J. Privett Limited, Copnor Road, Portsmouth.

Hastings. F. J. Parsons Limited, Cambridge Road. To make extensions to printing works at Prospect Place.

Hemel Hempstead. Ensign Accumulators Limited, Albert Works, Spencer Road, London N8 propose to build a new factory at Maylands Avenue.

Hereford. H. P. Bulmer & Co. Limited, Kings Acre Road, are to make extensions to their factory.

High Wycombe. Newland Foods (High Wycombe) Limited. Plans approved for the erection of a new factory at Wellington Road.

Inchicore, Eire. Brown & Polson (Ireland) Limited, Terenure, Dublin, are to build a new factory at Davitt Road. Architect, Michael Scott, 19 Merrion Square, Dublin.

Inverness. Scottish Industrial Estates Limited, 3 Woodside Place, Glasgow C3. To erect new factory at Longman.

Kilmarnock. Blackwood Morton and Son Limited. Permission received to erect a new spinning mill in Lawson Street.

Kirkcaldy. James Meikle & Co. Limited, Dysart. Permission received for extensions to Caledonia Mills, Prime Gilt Box Street.

Mitcham. Colloquid Cellulose Limited. To make extensions to their Harlequin Works, Willow Lane.

Peterborough. W. P. Hartley Limited. Plans approved for extensions to the factory at Westwood Airfield.

Portsmouth. Hinchley Engineering Company Limited, Unicorn Road. Factory extensions.

B. O. Morris Limited, Albion Works, Commercial Road. New factory and offices to be built in Zetland Road.

St. Albans. Lacre Lorries Limited, Bridge Road, Welwyn Garden City. New factory.

L. Bennett & Son, Normanby Road. To erect new workshop and offices at Valley Road industrial estate.

Salford. Garnetts Gresley Castors Limited, Ordsall Lane, are to rebuild their factory.

Shrewsbury. Salopian Industries (Metals) Limited, Whitchurch Road. Factory extensions. Architect, E. Carran, Church Preen, near Much Wenlock.

Swansea. D. Ayres Jones & Co. Limited. Extensions to the factory at Fforestfach.

Flair International Fashions. New factory to be built in Pontardulais Road.

Pressed Steel Company Limited. Large factory to be built to employ 2,000 people within 18 months of occupation and about 4,000 over the following four to five years.

Tottenham. Dailley & Co. Limited. To extend their works in Gorman Road.

Tunbridge Wells. Systematic Tooling Limited. New factory. Contractors, A. Roberts & Co. Limited, 79 Eccleston Square, London W1.

Walthamstow. F. Wrightson & Son Limited, Brampton Works, Billet Road. Factory extensions. Contractors, F. Davis Limited, 80 Dynecourt Gardens, London E11.

Warrington. Firth Company Limited. New factory to replace that destroyed by fire in December 1957, to be brought into production this month.

Rutherglen. British Chrome and Chemical Limited, chemical manufacturers. New factory in Glasgow Road, costing £504,000, for manufacture of bichromate of soda.

CLASSIFIED ADVERTISEMENTS

Classified advertisements are inserted at the rate of 2/9 per line.

Situations Vacant

MAINTENANCE ENGINEER. Preferable with building experience for medium size Company West London. Wood and allied Trades. Applicants interested in hard work and achievement rewarded—others need not apply. Salary according to ability, experience and personality. Minimum £620 p.a. Practical journeyman and sound supervisor required. Incentives/Bonus. Box AW.9. "Mechanical World", 31 King Street West, Manchester 3.

Machinery, Plant and Accessories For Sale

UNUSED 'Collis' Portable Elevating Trucks 50 cwt capacity, makers model C 6/10 £55. 0s. 0d. each.

Full details on request to Thos. W. Ward Limited, Albion Works, Sheffield. Phone: 26311. Ext. 305.

"FRIGIDAIRE" Low Temperature Refrigerators. 49 in.w × 28 in.d × 34 in.h ext. Ex Large National User, suitable A.C. or D.C. Deep Freezing, Storage of Ice Cream, Frozen Foods, etc. Price £40.0.0 each. Domestic Refrigerators, Service Cabinets and Cold Rooms also available. A.R.C., 134 Great Portland Street, London W1. MUSeum 4480.

FANS! ! ! for Dust, fume extraction, air conditioning, compressors, accessories, motors, etc.; at considerably reduced prices. People say—"If only we'd known of you before. . . . Write for very interesting list. Bellangers, 306 Holloway Road, London N7. North 4117.

PUMPS for all purposes. R. L. Christansen Limited, Wordesley, Stourbridge. Brierley Hill 7584.

Patents for Sale or License

THE Proprietor of British Patent No. 730675, entitled "Apparatus and Process for forming Helices from Metal Strips, Rods, Bars, Tubes and the Like", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietors of Patent No. 671413 for "Slings for Lifting and Lowering or for Forming Bundles" desire to secure commercial exploitation by License or otherwise in the United Kingdom. Replies to Haseltine Lake & Company, 28 Southampton Buildings, Chancery Lane, London WC2.

THE Proprietors of British Patent No. 733554 is prepared to sell the Patent or to license British manufacturers to work thereunder. It relates to "Improvements in Coupling Devices for Hose and the like". Address: Boult, Wade & Tennant, 112 Hatton Garden, London EC1.

THE Proprietor of British Patent No. 709099, entitled "Milling Machine", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 707617, entitled "Ejecting mechanism for punch presses", offers same for licenses or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 710725, entitled "Spraying Device", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 730350, entitled "Power-Operated Powder-Distributer", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 689695, entitled "Reversing Valve", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 729394, entitled "Pressure Relief Valve Assembly", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.

THE Proprietor of British Patent No. 730326, entitled "Hydraulic Ore Hoist", offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 14 E. Jackson Blvd., Chicago 4, Illinois, U.S.A.